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# LASER RANGE EVALUATION FOR THE SMOKY HILL AIR NATIONAL GUARD RANGE, SALINA, KANSAS

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ROBERT M. CARTLEDGE Lt col, USAF, BSC

Chief, Optical Radiation Division

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Major Thomas Ames, Detachment 1, Headquarters 184th Fighter Group, Smoky Hill Air National Guard Range, Salina, Kansas, requested a laser range evaluation in a letter dated 10 September 1994. TASC personnel (through a contract let by the Armstrong Laboratory) performed the evaluation on 7-9 November 1994. Subjects covered included lasers to be used and the various missions to be conducted on the ranges. Recommendations and footprint evaluations were made to provide effective use of the range terrain. Range compatibility for air-to-ground and ground-to-ground laser activities were evaluated for the range. A helicopter ground-to-ground lasing target was sited. Laser range procedures, laser goggle data, and laser training information were provided, as well as required medical surveillance requirements for range personnel. Range assessment consisted of an on-site (laser target) visit, review of range procedures, and an evaluation as detailed in checklists from MIL-HDBK-828 and the Range Commanders Council Document RCC-316-91 (see Appendix I of this report).

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# LASER RANGE EVALUATION FOR THE SMOKY HILL AIR NATIONAL GUARD RANGE Salina, Kansas

### INTRODUCTION

The Smoky Hill Air National Guard Range (SHANGR) laser evaluation was performed as requested by Major Ames of the 184th Fighter Group, Detachment 1, in his letter of 10 September 1994. The hazard analysis, range evaluation, and recommendation were accomplished on 7-9 November 1994, in accordance with AFOSH Std 161-10, MIL-HDBK-828, and USAFOEHL Report 87-091RCO111GLA for the purpose of ensuring range laser safety.

The primary objectives of this range visit were:

- 1. To evaluate laser target footprints for safe, effective range use during ground-to-ground and air-to-ground, fixed-wing and helicopter operations. Presently, very few laser missions are conducted at the range.
- 2. To provide laser information which may assist the rewriting of the SHANGR laser procedures.

### RANGE ASSESSMENT

### **Laser Systems**

Laser systems used on SHANGR are for ranging and target designation purposes for both air-to-ground and ground-to-ground missions.

The most frequently used laser system on SHANGR will be the Low-Altitude Navigation and Targeting Infrared for Night (LANTIRN) system mounted on F-16 and F-15E aircraft. Other systems such as the F-111 Pave Tack, F-117, TOW (LAAT), and OH-58D Laser Range Finder/Target Designator will also be used. Tables A-1, A-2, and A-3 (Appendix A) list all the known operational air-to-ground laser rangers and target designators currently in use by the US Air Force, US Army, and US Navy, respectively. Tables A-4 through A-7 (Appendix A) list all the ground-to-ground laser rangers and target designators currently used by the US Armed Forces. These lists include all pertinent and available information for the range evaluation and laser hazard calculations such as the wavelength, the laser classification, the nominal ocular hazard distance (NOHD), the required laser eye protection (LEP) optical density (OD), the buffer angle, etc. Appendix B contains a brief description of the USAF air-to-ground laser systems as well as their platforms and their laser hazard evaluations. The same information is provided for the other services' laser systems when available.

### LEP

The surveyed eye protection was proper and had the correct designations for 1064-nm lasers that would be used on the range. The eyewear did show scratches due to the fact they were not stored in protective covers. Covers would avoid scratches, dust, and degradation.

# The Range

SHANGR is located 11 miles southwest of Salina, Kansas. The range occupies 33,875 acres of DoD land. The complex is comprised of R-3601 A/B, the Smoky Military Operating Area (MOA) and Smoky HI MOA, all of which are controlled by the 184th Tactical Fighter Group, Kansas Air National Guard, Salina, Kansas.

Missions requiring high-altitude entry and maneuvering above 18,000 feet (FL180) are coordinated with FAA, Air Traffic Control Area Airspace (ATCAA). Range operations are coordinated for times, altitudes, and other traffic with Kansas City Center. The range does not have a radar to provide positive position of aircraft above the DoD target areas.

Farmland and residences border the range on all sides. The Salina airport is approximately 10 miles northeast, with traffic patterns parallel to the east boundary. However, the range is located on rolling terrain, which can be used effectively for laser backstops.

Hedberg Road, traversing west of Falun, KS, and HEI Road provide distinct landmarks on the south boundaries for controlling daylight laser operations. Effective lighting patterns have been set up for control points during night operations.

The present laser targets (Targets 90 and 91) in the east tactical range are 1 mile to the east and 1 1/2 miles beyond the control tower. These targets are scored by Television Optical Scoring System (TOSS) cameras. A prime helicopter lasing target was located in the southwest range near Coiner Point. The target is located in a deep valley near a treeline for additional backstop.

The range has many ponds located in low areas, which were mostly at low water levels due to the 1994 dry summer. These ponds fill in the spring, resulting in several areas of sheltered standing water.

An excellent night lighting system has been installed to provide accurate run-in headings and range identification markers.

# The Targets

Smoky Hill is a Class A range with over 100 static targets. Targets consist of runways, aircraft, AAA sites, artillery, bridges, convoys, C3 facilities, ground forces, a motor pool, POL

storages, radars, a railroad, SAM sites, SCUD missile, supply depot, and tanks. The laser targets are constructed from conex containers, painted to cover any metal surfaces. Many of the targets are locally manufactured silhouettes of nonreflective materials. They are also effectively using concrete legos.

The targets are well maintained. They are the cleanest and best-groomed of any range that I have seen.

Appendix C contains the range target maps. The map on page C-1 shows the entire Smoky Hill Range. Laser surface danger zones (LSDZs), based on worst-case Pave Tack profiles, around the targets are also annotated on all the maps. The maps include geographic items and the location of the present and a proposed new helicopter laser target.

Laser operations have been conducted on targets 90 and 91. The targets were constructed with dumpsters stacked together making each target 20 feet wide and 15 feet high. The southern target (91) is painted flat white with a dark cross painted on the south side. It has been used for BDU-33 deliveries. The north target (90) is painted gray and has been used for BDU-33 and GBU-10/12 inert deliveries.

Target No.	Туре	Coordinates	Elevation (feet)
90	Painted conex	N3842.986 W9749.757 (WGS-84)	1410
91	Painted conex	N3842.867 W9749.672	1420

Table 1. SHANGR, KS, Targets

# **The Flight Profiles**

The normal flight profiles to Smoky Hill Range are from the south on a heading of 008 degrees magnetic. This is due to the long north-south range boundaries and also due to the nearby towns. In addition, Salina airport traffic is parallel to the range profiles approximately ten miles due east.

SHANGR does not have radar control to monitor the lasing aircraft position. Therefore, direct communications between ground control and the airborne aircrew are the primary means of assuring the proper profile and targets are used.

Standard F-16 and F-15E LANTIRN profiles include laser firing at approximately 4 nautical miles during low (500 foot pop-up AGL) approaches and up to a range of 15 nautical miles from the target on medium altitude approaches at altitudes up to 25,000 feet (MSL).

# The Laser Surface Danger Zones (LSDZ)

Looking at the footprint calculation tables at Appendix E, one can see that the worst case or largest footprints are the following for the various delivery profiles:

Laser System	Forward	Footprint	Width
		Aft	
LANTIRN	4420 ft	3420 ft	127 ft
	1340m	1040 m	39 m
Pave Tack	6500 ft	4550 ft	176 ft
	1980 m	1390 m	54 m
Pave Spike	3730 ft	4250 ft	163 ft
	1140 m	1290 m	50 m

Table 2. Loft Delivery Footprints

Laser System	Forward	Footprint	Width
		Aft	
LANTIRN	51 ft	51 ft	58 ft
	16 m	16 m	18 m
Pave Tack	71 ft	71 ft	81 ft
	22 m	22 m	25 m
Pave Spike	66 ft	66 ft	75 ft
	20 m	20 m	23 m

Table 3. Medium-Altitude Delivery Footprints

Laser System	Forward	Footprint	Width
		Aft	
LANTIRN	650 ft	587 ft	51 ft
	198 m	179 m	15 m
Pave Tack	921 ft	800 ft	70 ft
	281 m	244 m	21 m
Pave Spike	845 ft	742 ft	65 ft
	258 m	226 m	20 m

Table 4. "Buddy Lasing" Delivery Footprints

One can see from the data given in Table 2 that the largest footprint is the one for the Loft Delivery Profile using the Pave Tack laser (Footprint: Forward = 6500 ft, Aft = 4550 ft, Width = 176 ft).

We did some preliminary hazard evaluations on some of the Navy's air-to-ground laser systems (see Appendix E). However, at this point we do not have enough information on the beam divergence and buffer angles to make reasonable footprint calculations. We had to use some very large values (worst-case) for both divergence and buffer angles; consequently, the preliminary results are overly restrictive.

# CONCLUSIONS/RECOMMENDATIONS

The SHANGR personnel have been recognized by ACC for having a very clean and well-groomed range, with a large number of useable targets. The range personnel are well qualified, and the RCO/LSO and the Range Commander are both on flying status in current aircraft such as the F-16 and B-1. The targets they have selected for laser operations are well situated (for laser safety) on the Smoky Hill complex. The LSDZs are entirely within the tactical ranges and approximately 3 kilometers from the nearest reservation boundaries.

### **Range Control**

Positive aircraft monitoring and control will be required during lasing operations, due to the narrow range width and the lack of radar coverage. This can be accomplished with the LSO calling "Cleared to Lase" AFTER the pilot or crew member calls "Target Acquired" when passing an initial point (IP). Crew members must also make "Laser ON" and "Laser OFF" calls to assure the laser is maintained in the LSDZ.

Range approach headings between 350 and 010 degrees magnetic are recommended for laser targets 90 and 91. These headings would be consistent with the present Smoky Hill flight patterns. Night missions would use the lighted heading of 008 degrees magnetic.

Recommend the access roads have barriers or control points since they are the main route between the headquarters and the range control facilities. The road is crossed by the lasing aircraft flight path.

Lasing by Apache or Cobra helicopters will be safest when the deepest canyons, with wooded areas and hills as backstops, are used. The area south of Coiner Dome is a prime target area. Recommend run-in headings of approximately 110 to 150 degrees magnetic to keep the laser beam hazard footprint within the range boundaries. This will provide rolling hills for approaches and backstops, while providing a 4-km run-in approach path and 5-km buffer beyond the target area.

We highly recommend the Smoky Hill Range Officer invite using units to visit the range, thus assuring the current operational scenarios match the proposed target arrangement (tactics seem to have a way of changing as a result of recent peacekeeping activities, aircraft modernization, and Red Flag exercises). The aircraft crew members must be briefed on major

control landmarks, flight profiles, and communications for the missions. All the ground personnel must also know flight profiles over their location and times of laser operations. The aircrews must be notified of the locations of any ground personnel they could be flying over. Smoky Hill controllers are key players in coordinating and scheduling aircrews.

# **Laser Footprint**

Laser footprint information (Appendix E) was provided at the time of the visit and is also included in this report (see LSDZ section). The information was designed for level terrain, which will also be conservative for Smoky Hill Range, since the elevations range from near 400 meters to a peak of 481 meters at Soldier Cap Mound.

The map on page C-1 depicts the laser targets and LSDZs/Nominal Hazard Zones (NHZs) for SHANGR/Smoky Hill Air Force Range.

A laser hazard footprint from the Pave Tack loft profile (see Table 2, the worst-case 1064-nm scenario) is shown by solid line arcs. The solid line circles on the maps are extensions of the "forward laser hazard zone" (6500-foot radius to a full circle). This allows maneuvering headings within the Smoky Hill Range, as required for "buddy lasing." Overlapping circles depict the use of laser footprints for more than one target. All other 1064-nm airborne systems listed in the table will fall within these safety footprints.

The map on page C-2 depicts the laser targets in relation to the other targets in that portion of the range and shows the nighttime approach/run-in line used for nighttime profiles.

The map on page C-3 is a layout of the recommended approach headings to allow maximum range area use and provide safe operations in relation to the surrounding towns and Salina airport traffic.

# Scheduling

A primary safety factor for laser operations range control is scheduling with all the range users. The aircraft crew members must be briefed on control landmarks, flight profiles, laser footprints, and communication requirements for their particular missions. The aircrew must be notified of the locations of any ground parties they could be flying over. All ground personnel must also know flight profiles over their location and times of laser operations. Smoky Hill laser range controllers are key players in coordinating and scheduling with aircrews and range personnel. All laser missions actually flown on the range should be recorded in a "Laser Mission Log." This will be beneficial during investigations or legal actions, if such actions become necessary.

# **Water Reflection**

The laser safety officer and aircrew members must also understand that laser beams can be reflected from standing water. The condition of smooth standing water requires consideration of aircraft potentially flying in areas of reflected laser beams. As a guide, use a minimum of 1/2 of the NOHD beyond the target for a hazard reflection distance. As an example, for LANTIRN with an NOHD of 22,700 meters, the beam could extend 11,350 meters beyond the water surface at an angle equal to the aircraft true lasing azimuth angle. With low flat approaches, the reflected beam could extend beyond range boundaries.

# **Laser Training**

Laser safety training is highly recommended for aircrew and personnel controlling laser operations, writing laser procedures, and representing ranges at meetings or conferences. Range controllers and managers are directly responsible for implementing safe laser procedures and protecting all the range users. They should be fully qualified in range operations. This training is the responsibility of the Range Safety Officer and the support Public Health Officer. The assigned flight surgeon and bioenvironmental engineering services can assist in parts of this training. Training should be conducted and properly documented. Training material can be obtained from AL/OEO (SSgt Limburg), DSN 240-4785, at Brooks AFB.

# **LEP**

LEP with minimum OD of 4.0 is recommended for currently used 1064-nm neodymium:yttrium-aluminum-garnet (Nd:YAG) lasers. It is highly recommended that the old eyewear be replaced with new and more useable protection. Ensure that the protected wavelength (1064 nm) and the OD at this wavelength are printed on the glasses. Eyewear should be stored in containers in a dry location to reduce deteriorating effects. Laser eyewear can be procured using Federal Stock Number 4240-00-620-0054 from Glendale Protective Technologies or several companies listed in Appendix G.

### **Procedures**

Copies of the general laser procedures and footprint data were provided to Smoky Hill Range personnel to assist in the rewrite of their range procedures. Additional laser safety information can be found in MIL-HDBK-828, April 1993, "Military Handbook Laser Range Safety," or ANSI Z136.1-1993 "American National Standard for the Safe Use of Lasers," and USAFOEHL Report 87-091RC0111GLA, July 1987 "Laser Range Evaluation Guide for Bioenvironmental Engineers." AFOSH 161-10 is being revised and will be published in late 1995 as AFI 48-10.

We will also review any of your future procedure revisions if you desire.

# **Medical Records**

Medical records were not reviewed during this visit; however, current documentation for eye examination requirements are included for range manager's guidance (see Appendixes F&J). Coordination with the local hospitals will establish procedures and shorten processing activities if a laser incident should occur.

If any questions should arise contact Lt Pat Hoisington (DSN 240-4784) or SSgt Jerry Limburg (DSN 240-4785/4779) at Brooks AFB, TX.

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# APPENDIX A

Air-to-Ground Laser Systems and Ground-to-Ground Laser Systems

# TABLE A-1. USAF AIR-TO-GROUND LASER SYSTEMS

				4	
Beam Divergence	0.35	1.8		0.33	0.18
Buffer Angle (mrad)	2.5	2	2	5	2 N/A
0-Q0	4.02 5.71	7.24		5.4	4.15 5.84 0 0
ОО	4.02	5.55	3.7	3.7	4.15
NOHD-0 (km)	73.5	16.1		63	157 0
NOHD. (km)	10.4	2.3	5.6	8.89	22.7 0
ANSI	4	4	4	4	4 · 3b
Wavelength (nm)	1064	1064	1064	1064	1064 1540
Device	Pave Spike (AN/ASQ-153)	Pave Tack (AN/AVQ-26)	Pave Knife (AN/ALQ-10)	Pave Spectre (AN/AVQ-19)	LANTIRN operational training

OD-0 - OD needed for optical instruments (7 x 50) NOHD-0 - NOHD with optical instruments (7 x 50) (7 x 50: 7x magnifying power, 50-mm aperture) Notes:

TABLE A-2. U.S. ARMY AIR-TO-GROUND LASER SYSTEMS

-	Beam Divergence (mrad)		
	Buffer Angle (mrad)	2	2
	OD OD-0 Buffer Angle (mrad	4.0 5.5	4.1 5.3
	ОD	4.0	4.1
•	NOHD-0 (km)	45	26
•	NOHD (km)	20	32
•	ANSI	4	4
•	Wavelength (nm)	1064	1064
•	Device	TADS (AAH) (Apache)	OH-58D

OD-0 - OD needed for optical instruments (7 x 50) NOHD-0 - NOHD with optical instruments (7 x 50) (7 x 50: 7x magnifying power, 50-mm aperture) Notes:

USN & USMC AIR-TO-GROUND LASER SYSTEMS TABLE A-3.

Buffer Angle (mrad)	5	2	5	5	2	10	10
0-00 00-0	4.8	5.8	5.6	5.4	5.2	1.7	1.7
ОО	3.5	4.6	5.2	4.3	4.1	1.7	1.7
NOHD-0 (km)	15		45	20	45	.68	.68
NOHD (km)	5	14.6	11.2	17	15	.085	.085
ANSI	4	4	4	4	4	3b	3b
Wavelength (nm)	1064	1064	1064	1064	1064	800	850
Device	LAAT (AH1S) (MC)	AN/AAS-33A (AGE TRAM)	AN/AAS-37 (OV-10D NOS)	AN/AAS-38A (F18)	Nite Eagle (MC-Cobra) UH-1N	AIM-1/MLR	AIM-1/EXL

OD-0 - OD needed for optical instruments (7 x 50) NOHD-0 - NOHD with optical instruments (7 x 50) (7 x 50: 7x magnifying power, 50-mm aperture) Notes:

# TABLE A-4. GROUND-TO-GROUND LASER SYSTEMS

(Tank Mounted)

Buffer Angle (mrad)	Moving	Not Permitted	10	5	N/A	w
Buffer An	Static	2	5	2	N/A	2
တ	(m)	60	100	60 Target	0	09
+	(m)	10	10	10	0	0
NOHD-0 (km)		80	80	80	0	35
NOHD (km)		10	10	10.300	0	7
ANSI Class	·	4	4	4		4
Device		AN/VVG-1	AN/VVS-1	AN/VVG-2 red filter (29db)	green filter (55db)	AN/VVG-3

Notes: NOHD - Multiple-pulse NOHD

NOHD-0 - NOHD with optical instruments (7 x 50)

t - diffuse reflection hazard distance

s - a predetermined (by the using service) distance around the target which must be cleared of specular reflective surfaces

(7 x 50: 7x magnifying power, 50-mm aperture)

# TABLE A-5. GROUND-TO-GROUND LASER SYSTEMS

# (Tank Mounted)

Required   OD	5 5.8	5 5.8	5 5.8	4.7
Built-in OD	Clip-on > 5	Clip-on > 5	Clip-on > 5	> 5
Wavelength (nm)	694.3	694.3	694.3	1064
Device	AN/VVG-1	AN/VVS-1	AN/VVG-2	AN/VVG-3

TABLE A-6. GROUND-TO-GROUND LASER SYSTEMS

(Man Portable)

Device	ANSI	OHON	0-QHON	+	S	Buffer Angle (mrad)	(mrad)	
	Class	(km)	(km)	(m)	(m)	Static	Moving	
AN/GVT-1	1	0	0	0	0	N/A	N/A	
LLTD		7		0	200	10	N/A	
AN/GVS-5 (haŋdheld)	4	2.7	20.6	0	200	10	N/A	
red filter (19db) yellow filter (29db)		.29	1.8	00	200	10	X	
AN/PAQ-1 (handheld) target designator	4	2.7	33	0.	200	10	N/A	
CLD		9.7		0	200	10	N/A	
AN/TVQ-2 Rangefinder w/ yellow filter (8.5db)	4	8	40	00	60	2 on tripod 5 on vehicle	A/N 4/N	r
Designator	. 4	25	80	0	60	2 on tripod	(	
					001	on venicle	N/A	

TABLE A-6 (continued)

le (mrad)	Moving	>	N/A	N/A	N/A	N/A	N/A	degrees		10	10
Buffer Angle (mrad)	Static		2 on tripod	10 on vehicle	2 on tripod	10 on vehicle	5	06		10	10
v	(m)		09	200	09	200	200	200		30	20
	(m)		0		0		0	0		0	0
NOHD-0	(km)		35		62		1	16		 	89.
NOHD	(km)		6.5	1	20		12.5	3 single	bnise	0.1	.095
ANSI			4		4						
Device		AN/PAQ-3 (mule)	Rangefinder		Designator		AN/GAQ-TI	AN/PVS-X	Kangetinder	TD-100	LPL-30

Notes: NOHD - Multiple-pulse NOHD

NOHD-0 - NOHD with optical instruments (7 x 50)

t - diffuse reflection hazard distance

s - a predetermined (by the using service) distance around the target which must be cleared of specular reflective surfaces

(7 x 50: 7x magnifying power, 50-mm aperture)

# TABLE A-7. GROUND-TO-GROUND LASER SYSTEMS

# (Man Portable)

Device	Wavelength (nm)	Built-in OD	Required OD
AN/GVT-1	1064	N/A	0
AN/GVS-5	1064	2	3.7
AN/PAQ-1	1064	4	4.2
AN/TVQ-2	1064	yes	3.8
AN/PAQ-3	1064	> 5	3.9
AN/GAQ-T1	1064	yes	4.6
LLTD	1064 1064	\ \	4.0
LPL-30	800-850	1.7	1.7

Notes: The built-in OD only protects against the wavelength of the laser in which it is installed.

# APPENDIX B

Description and Hazard Evaluation of the Laser Systems

### Description of Fielded Laser Systems

- a. AN/VVS-1: Laser Range Finder mounted on the M60A2 tank.
- b. AN/VVG-1: Laser Range Finder mounted on the M551A1 Sheridan vehicles.
- c. AN/VVG-2: Laser Range Finder mounted on the M60A3 tank. Used with two filters, the green Eye Safe Simulated Laser Range Finder (ESSLR) filter and the red ESSLR filter. The green ESSLR is eye safe, the red ESSLR is less hazardous than the system without filters.
  - d. AN/VVG-3: M1 tank laser rangefinder used with one eyesafe filter.
  - e. AN/GVS-5: Laser Range Finder Infrared Observation Set (Handheld).
- f. AN/PAQ-1: (LTD) Laser Target Designator. This is a lightweight, handheld, battery operated laser device. Forward observers use it to designate targets.
- g. AN/TVQ-2: (G/VLLD) Ground/Vehicle Laser Locator Designator. This is a ranging and laser designating device used by Army artillery forward observers with laser energy homing munitions. It is capable of designating stationary or moving vehicular targets and may be used in a stationary, vehicle mounted, or tripod supported dismounted mode. The primary vehicle mount is the Fire Support Team Vehicle (FISTV).
- h. AN/PAQ-3: (MULE) Modular Universal Laser Equipment. This is a Marine Corps laser designator used with laser energy homing munitions. The MULE is man portable and is used only in a dismounted mode.
- i. Laser Augmented Airborne TOW (LAAT) mounted in the AH-1S COBRA Helicopter. The LAAT system consists of a laser range finder and receiver that is incorporated into the M65 tube launched, optically tracked, wire guided (TOW) telescopic sight unit.
- j. Target Acquisition and Designation System with Pilot Night Vision Sight (TADS/PNVS) mounted in the Apache Advanced Attack Helicopter.
- k. Mast Mounted Sight on the OH-58D that, in addition to thermal and optical sensors and imaging instrumentation, incorporates a laser rangefinder and/or designator.
- l. AN/AAS-37: Laser Range Finder Designator mounted on the Marine Corps  $\,$  OV-10 Observation Aircraft.
- m. AN/AAS-33A: Target Recognition Attach Multisensor (TRAM) laser system. This system is mounted on the A6-E Aircraft and has a laser target designator and forward looking infrared (FLIR).
- n. LANTIRN System: Low Altitude Navigation and Targeting Infrared System for Night. A two-pod system containing a terrain following radar (TFR), two forward looking infrared (FLIR) sensors, a laser designator/ranger, and later, a target recognition system. This system is designed to be flown on the F-15, F-16, and A-10. The laser operates at 1064 nm and has a training modification to allow operation at 1540 nm which is "eye safe."
- o. PAVE SPECTRE (AN/AVQ-19): Laser tracker and designator used on C-130 gunships.
- p. PAVE SPIKE (AN/AVQ-12): Laser tracker and designator pod fitted on F-4 and F-111 aircraft.

- q. PAVE TACK (AN/AVQ-26): Advanced optronics pod containing stabilized turret with FLIR, laser designator and tracker used on the F-4, RF-4, and F-111F aircraft.
- r. COMPACT LASER DESIGNATOR (CLD): A small, lightweight laser designator and/or rangefinder used by the Navy for target designation.
- s. TD-100: A day/night aiming laser. For daytime use this device uses a class 2 helium neon visible laser and for nighttime it uses a class 3b infrared laser diode. Night vision goggles will provide adequate nighttime protection for anyone viewing the infrared laser.
- t. AIM-1: A class 3b infrared diode aiming laser for use with night vision goggles. The AIM/MLR is mounted on USAF and Marine Corps 50 caliber helicopter gun mounts. The AIM/EXL version is hard mounted on the AH-1 turret.
- u. LPL-30: A class 3b infrared diode aiming laser used by command to indicate targets of choice to attacking forces equipped with the night vision goggles.

### LASER HAZARD EVALUATION

### LANTIRN 1064 nm

A. A hazard evaluation was accomplished for a laser with the following operational characteristics:

Wavelength = 1064.00 nm Energy/pulse = 1.70E-01 Joules/pulse Pulsewidth = 15.00 nsec PRF = 2.00E+01 Hz Beam Diameter = 3.38 cm at 1/e point Divergence = 0.18 mradians at 1/e point

- B. This is an ANSI Class 4 Laser and should be operated in accordance with the safety measures outlined in AFOSH Std 161-10 along with such other safety procedures required by the responsible safety officer.
- C. The Maximum Permissible Exposure (MPE) limits are listed below. The MPE is defined as the radiant exposure which personnel may receive without adverse biological effects.

### Single Pulse MPEs

Type of MPE	Exposure Duration (s)	MPE
Ocular point source	1.50E-08	5.00E-06 J/cm2
Ocular extended source	1.50E-08	1.23E-01 J/cm2/sr
Skin	1.50E-08	1.00E-01 J/cm2

### Multiple Pulse MPEs

Type of MPE	Exposure Duration (s)	MPE/pulse
Ocular point source Ocular point source Ocular point source Ocular extended source Ocular extended source Ocular extended source Skin Skin Skin	2.50E-01 1.00E+01 3.00E+04 2.50E-01 1.00E+01 1.00E+04 2.50E-01 1.00E+01 3.00E+04	3.34E-06 J/cm2 1.33E-06 J/cm2 1.80E-07 J/cm2 6.30E+00 J/cm2/sr 5.38E-01 J/cm2/sr 1.60E-01 J/cm2/sr 1.00E-01 J/cm2 4.89E-02 J/cm2 5.00E-02 J/cm2

D. The Nominal Ocular Hazard Distance (NOHD) for various exposure conditions is listed below. The NOHD is defined as the distance from the laser where the radiant exposure is equal to the MPE.

### NOHD

Type of NOHD	Exposure Duration (s)	(m)	(ft)
Ocular point	1.50E-08	1.16E+04	3.82E+04
Ocular point	2.50E-01	1.43E+04	4.68E+04
Ocular point	1.00E+01	2.27E+04	7.46E+04
Ocular point	3.00E+04	6.22E+04	2.04E+05
Diffuse reflection	1.50E-08	0.00E+00	0.00E+00
Diffuse reflection	2.50E-01	0.00E+00	0.00E+00
Diffuse reflection	1.00E+01	0.00E+00	0.00E+00
Diffuse reflection	3.00E+04	0.00E+00	0.00E+00
Skin	1.50E-08	0.00E+00	0.00E+00
Skin	2.50E-01	0.00E+00	0.00E+00
Skin	1.00E+01	0.00E+00	0.00E+00
Skin	3.00E+04	0.00E+00	0.00E+00

E. The optical density (OD) is a measure of the opacity to radiation expressed in logarithmic units. The following are OD values required at the distances listed.

# OD Required at the Laser Aperture

Wavelength (nm)	Exposure Time (s)	Ocular OD	Skin OD
1064.0 1064.0 1064.0 1064.0	1.50E-08 2.50E-01 1.00E+01 3.00E+04	3.58 3.75 4.15 5.02	0.00 0.00 0.00 0.00
	OD Required at 100 meters from t	he Laser	
Wavelength (nm)	Exposure Time (s)	Ocular OD	Skin OD .

1.50E-08

2.50E-01

1.00E+01 3.00E+04

1064.0

1064.0

1064.0

3.21

3.39

4.66

0.00

0.00 0.00 0.00

### LASER HAZARD EVALUATION

### LANTIRN 1540 nm

A. A hazard evaluation was accomplished for a laser with the following operational characteristics.

Wavelength = 1540.00 nm Energy/pulse = 2.20E-02 Joules/pulse Pulsewidth = 17.00 nsec PRF = 1.00E+00 Hz Beam Diameter = 3.38 cm at 1/e point Divergence = 0.18 mradians at 1/e point

- B. This is an ANSI Class 3b Laser and should be operated in accordance with the safety measures outlined in AFOSH Std 161-10 along with such other safety procedures required by the responsible safety officer.
- C. The Maximum Permissible Exposure (MPE) limits are listed below. The MPE is defined as the radiant exposure which personnel may receive without adverse biological effects.

### Single Pulse MPEs

Type of MPE	Exposure Duration (s)	MPE
Ocular or Skin	1.70E-08	1.00E+00 J/cm2
	Multiple Pulse MPEs	
Type of MPE	Exposure Duration (s)	MPE/pulse
Ocular or Skin Ocular or Skin Ocular or Skin	2.50E-01 1.00E+01 3.00E+04	1.41E+00 J/cm2 5.62E-01 J/cm2 7.60E-02 J/cm2

D. The Nominal Ocular Hazard Distance (NOHD) for various exposure conditions is listed below. The NOHD is defined as the distance from the laser where the radiant exposure is equal to the MPE.

## NOHD

Exposure Duration (s)	(m)	(ft)
1.70E-08	0.00E+00	0.00E+00
2.50E-01	0.00E+00	0.00E+00
1.00E+01	0.00E+00	0.00E+00
3.00E+04	0.00E+00	0.00E+00
1.70E-08	0.00E+00	0.00E+00
2.50E-01	0.00E+00	0.00E+00
1.00E+01	0.00E+00	0.00E+00
3.00E+04	0.00E+00	0.00E+00
	1.70E-08 2.50E-01 1.00E+01 3.00E+04 1.70E-08 2.50E-01 1.00E+01	1.70E-08 2.50E-01 1.00E+01 3.00E+04 1.70E-08 2.50E-01 1.00E+01 0.00E+00 0.00E+00 0.00E+00 0.00E+00

E. The optical density (OD) is a measure of the opacity to radiation expressed in logarithmic units. The following are OD values required at the distances listed.

# OD Required at the Laser Aperture

Wavelength (nm)	Exposure Time (s)	Ocular OD	Skin OD
1540.0 1540.0 1540.0 1540.0	1.70E-08 2.50E-01 1.00E+01 3.00E+04	0.00 0.00 0.00-	0.00 0.00 0.00 0.00
	OD Required at 100 meters from	the Laser	
Wavelength (nm)	Exposure Time (s)	Ocular OD	Skin OD

Wavelength (nm)	Exposure Time (s)	Ocular OD	Skin OI
1540.0 1540.0 1540.0 1540.0	1.70E-08 2.50E-01 1.00E+01 3.00E+04	0.00 0.00 0.00 0.00	0.00 0.00 0.00 0.00
1540.0	3.00E+04	0.00	0.00

The 1540-nm training mode is also "eye safe" when using optics of up to  $20\mathrm{X}$  magnification.

### LASER HAZARD EVALUATION

### PAVE SPECTRE AN/AVQ-19

A. A hazard evaluation was accomplished for a laser with the following operational characteristics:

Wavelength = 1064.00 nm Energy/pulse = 1.10E-01 Joules/pulse Pulsewidth = 18.00 nsec PRF = 1.00E+01 Hz Beam Diameter = 4.18 cm at 1/e point Divergence = 0.33 mradians at 1/e point

- B. This is an ANSI Class 4 Laser and should be operated in accordance with the safety measures outlined in AFOSH Std 161-10 along with such other safety procedures required by the responsible safety officer.
- C. The Maximum Permissible Exposure (MPE) limits are listed below. The MPE is defined as the radiant exposure which personnel may receive without adverse biological effects.

### Single Pulse MPEs

Type of MPE	Exposure Duration (s)	) MPE
Ocular point source	1.80E-08	5.00E-06 J/cm2
Ocular extended source	1.80E-08	1.31E-01 J/cm2/sr
Skin	1.80E-08	1.00E-01 J/cm2

### Multiple Pulse MPEs

Ocular point source       2.50E-01       3.98E-06 J/cm2         Ocular point source       1.00E+01       1.58E-06 J/cm2         Ocular point source       3.00E+04       2.14E-07 J/cm2         Ocular extended source       2.50E-01       1.26E+01 J/cm2/sr         Ocular extended source       1.00E+01       1.08E+00 J/cm2/sr         Ocular extended source       3.00E+04       3.20E-01 J/cm2/sr         Skin       2.50E-01       1.00E-01 J/cm2         Skin       1.00E+01       9.78E-02 J/cm2         Skin       3.00E+04       1.00E-01 J/cm2	Type of MPE	Exposure Duration (s)	MPE/pulse
•	Ocular point source Ocular point source Ocular extended source Ocular extended source Ocular extended source Skin Skin	1.00E+01 3.00E+04 2.50E-01 1.00E+01 3.00E+04 2.50E-01 1.00E+01	1.58E-06 J/cm2 2.14E-07 J/cm2 1.26E+01 J/cm2/sr 1.08E+00 J/cm2/sr 3.20E-01 J/cm2/sr 1.00E-01 J/cm2 9.78E-02 J/cm2

D. The Nominal Ocular Hazard Distance (NOHD) for various exposure conditions is listed below. The NOHD is defined as the distance from the laser where the radiant exposure is equal to the MPE.

### NOHD

Type of NOHD	Exposure Duration (s)	(m)	(ft)
Ocular point	1.80E-08	4.95E+03	1.62E+04
Ocular point	2.50E-01	5.56E+03	1.82E+04
Ocular point	1.00E+01	8.89E+03	2.92E+04
Ocular point	3.00E+04	2.44E+04	8.01E+04
Diffuse reflection	1.80E-08	0.00E+00	0.00E+00
Diffuse reflection	2.50E-01	0.00E+00	0.00E+00
Diffuse reflection	1.00E+01	0.00E+00	0.00E+00
Diffuse reflection	3.00E+04	0.00E+00	0.00E+00
Skin	1.80E-08	0.00E+00	0.00E+00
Skin	2.50E-01	0.00E+00	0.00E+00
Skin	1.00E+01	0.00E+00	0.00E+00
Skin	3.00E+04	0.00E+00	0.00E+00

E. The optical density (OD) is a measure of the opacity to radiation expressed in logarithmic units. The following are OD values required at the distances listed.

# OD Required at the Laser Aperture

Wavelength (nm)	Exposure Time (s)	Ocular OD	Skin OD
1064.0	1.80E-08	3.20	0.00
1064.0	2.50E-01	3.30	0.00
1064.0	1.00E+01	3.70	0.00
1064.0	3.00E+04	4.57	0.00

### LASER HAZARD EVALUATION

### LHAZ VER 2.0

### PAVE SPIKE

A. A hazard evaluation was accomplished for a laser with the following operational characteristics:

Wavelength = 1064.00 nm
Multiple Pulse Laser
Energy = 1.68E-01 Joules/pulse
Pulsewidth = 1.50E-08 sec
PRF = 1.00E+01 Hz
Beam diameter = 3.59E+00 cm at 1/e point
Divergence = 3.50E-04 radians at 1/e point

- B. This is an ANSI Class 4 Laser and should be operated in accordance with the safety measures outlined in AFOSH Std 161-10 along with such other safety procedures required by the responsible safety officer.
- C. The Maximum Permissible Exposure (MPE) limits are listed below. The MPE is defined as the radiant exposure which personnel may receive without biological effects.

Type of MPE	Exposure Duration (s)	MPE
Ocular point source Ocular extended source Skin Skin Skin Skin	0.25 10.0 30,000	5.00E-06 J/cm2 9.94E-06 J/cm2 1.58E-04 J/cm2 6.41E-02 J/cm2 2.81E-05 J/cm2 1.23E-01 J/cm2/sr 3.08E-01 J/cm2/sr 1.23E+01 J/cm2/sr 9.60E+04 J/cm2/sr 1.23E+00 J/cm2/sr 1.00E-01 J/cm2 2.50E-01 J/cm2 1.00E+04 J/cm2 1.00E+04 J/cm2 1.00E+04 J/cm2
		,

D. The Safe Exposure Distance (SED)/Nominal Ocular Hazard Distance (NOHD) for various exposure conditions is listed below. The SED is defined as the distance from an operating laser at which the radiant exposure is equal to the MPE.

# SED/NOHD

Type of SED/NOHD	Exposure Duration (s)	(m)
Ocular point	Single Pulse	5.81E+03
Ocular point	0.25	6.52E+03
Ocular point	10.0	1.04E+04
Ocular point	30,000	_ 2.85E+04
Ocular point	1.000	7.78E+03
Diffuse reflection	Single Pulse	0.00E+00
Diffuse reflection	0.25	0.00E+00
Diffuse reflection	10.0	0.00E+00
Diffuse reflection	30,000	0.00E+00
Diffuse reflection	1.000	0.00E+00
Skin	Single Pulse	0.00E+00
Skin	0.25	0.00E+00
Skin	10.0	0.00E+00
Skin	30,000	0.00E+00
Skin	1.000	0.00E+00

E. The optical density (OD) is a measure of the opacity to radiation expressed in logarithmic units. The following are OD values required at the distances listed.

### OD Required at the Laser Aperture

or required at the laber aperture			
Wavelength (nm)	Exposure Time (s)	Ocular OD	Skin OD
1064.0	Single Pulse	3.52	0.00
1064.0	0.25	3.62	0.00
1064.0	10.0	4.02	0.00
1064.0	30,000	4.89	0.00
1064.0	1.000	3.77	0.00
1064.0	1.000	3.77	0.00
	OD Required at 1.0	km	
Wavelength (nm)	Exposure Time (s)	Ocular OD	Skin OD
1064.0	Single Pulse	1.46	0.00
1064.0	0.25	1.56	0.00
1064.0	10.0	1.96	0.00
1064.0	30,000	2.83	0.00
1064.0	1.000	1.71	0.00
1004.0	2.000		
	OD Required at 5.0	km	
Wavelength (nm)	Exposure Time (s)	Ocular OD	Skin OD
1064.0	Single Pulse	0.13	0.00
1064.0	0.25	0.23	0.00
1064.0	10.0	0.63	0.00
1064.0	30.000	1 50	0.00

30,000

1064.0

1.50

0.00

### LASER HAZARD EVALUATION

### LHAZ VER 2.0

### PAVE TACK

A. A hazard evaluation was accomplished for a laser with the following operational characteristics:

Wavelength = 1064.00 nm
Multiple Pulse Laser
Energy = 1.80E-01 Joules/pulse
Pulsewidth = 2.50E-08 sec
PRF = 2.00E+01 Hz
Beam diameter = 4.50E-01 cm at 1/e point
Divergence = 1.80E-03 radians at 1/e point

- B. This is an ANSI Class 4 Laser and should be operated in accordance with the safety measures outlined in AFOSH 161-10 along with such other safety procedures required by the responsible safety officer.
- C. The Maximum Permissible Exposure (MPE) limits are listed below. The MPE is defined as the radiant exposure which personnel may receive without biological effects.

Type of MPE	Exposure Duration (s)	MPE
Ocular extended source Ocular extended source Skin	0.25 10.0 30,000 1.000 Single Pulse	5.00E-06 J/cm2 1.67E-05 J/cm2 2.66E-04 J/cm2 1.08E-01 J/cm2 4.73E-05 J/cm2 1.46E-01 J/cm2/sr 7.31E-01 J/cm2/sr 2.92E+01 J/cm2/sr 9.60E+04 J/cm2/sr 2.92E+00 J/cm2/sr 1.00E-01 J/cm2
Skin Skin Skin Skin	0.25 10.0 30,000 1.000	5.00E-01 J/cm2 1.00E+01 J/cm2 3.00E+04 J/cm2 2.00E+00 J/cm2

D. The Safe Exposure Distance (SED)/Nominal Ocular Hazard Distance (NOHD) for various exposure conditions is listed below. The SED is defined as the distance from an operating laser at which the radiant exposure is equal to the MPE.

# SED/NOHD

Type of SED/NOHD	Exposure Duration (s)	(m)
Ocular point	Single Pulse	1.19E+03
Ocular point	0.25	1.45E+03
Ocular point	10.0	2.30E+03
Ocular point	30,000	- 6.27E+03
Ocular point	1.000	1.73E+03
Diffuse reflection	Single Pulse	1.07E+00
Diffuse reflection	0.25	1.31E+00
Diffuse reflection	10.0	2.08E+00
Diffuse reflection	30,000	5.65E+00
Diffuse reflection	1.000	1.56E+00
Skin	Single Pulse	5.91E+00
Skin	0.25	5.91E+00
Skin	10.0	9.39E+00
Skin	30,000	9.39E+00
Skin	1.000	5.91E+00

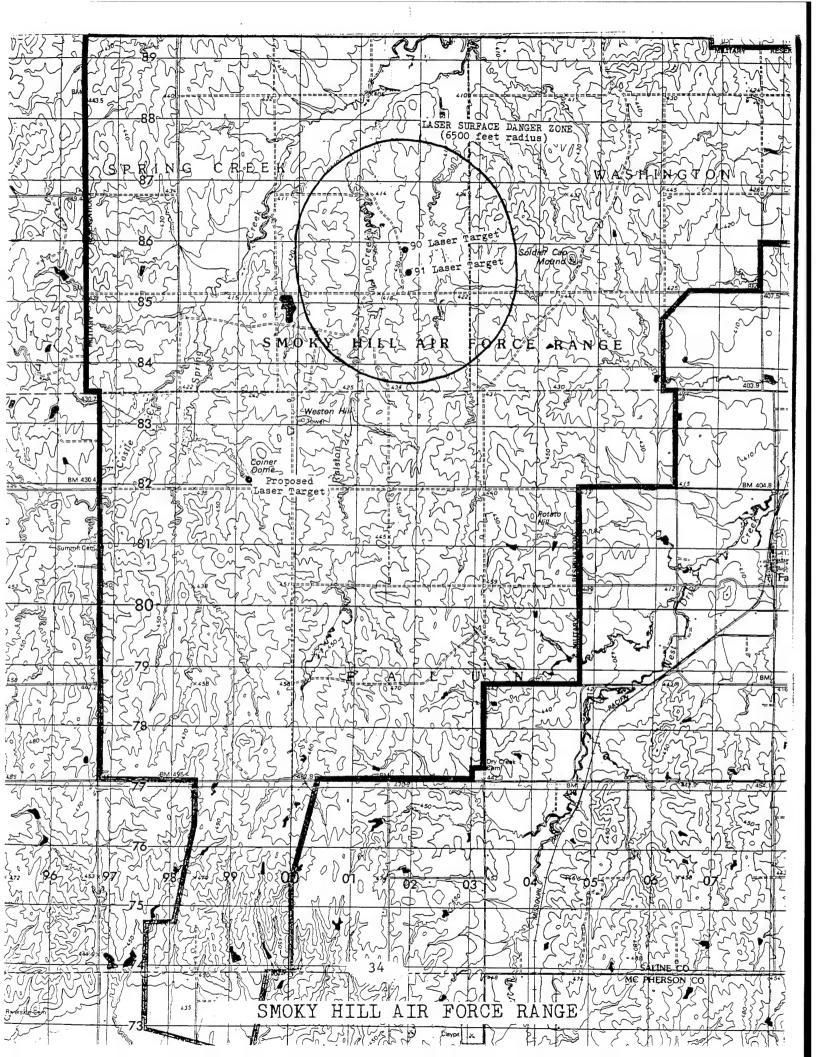
E. The optical density (OD) is a measure of the opacity to radiation expressed in logarithmic units. The following are OD values required at the distances listed.

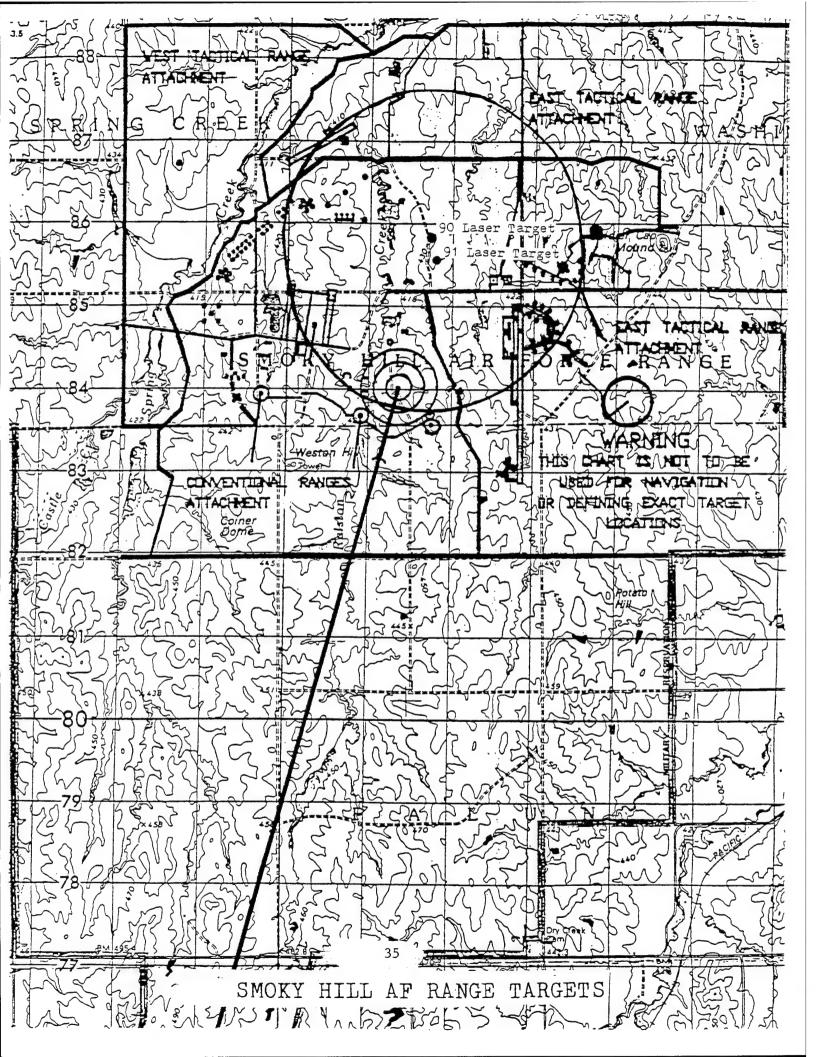
### OD Required at the Laser Aperture

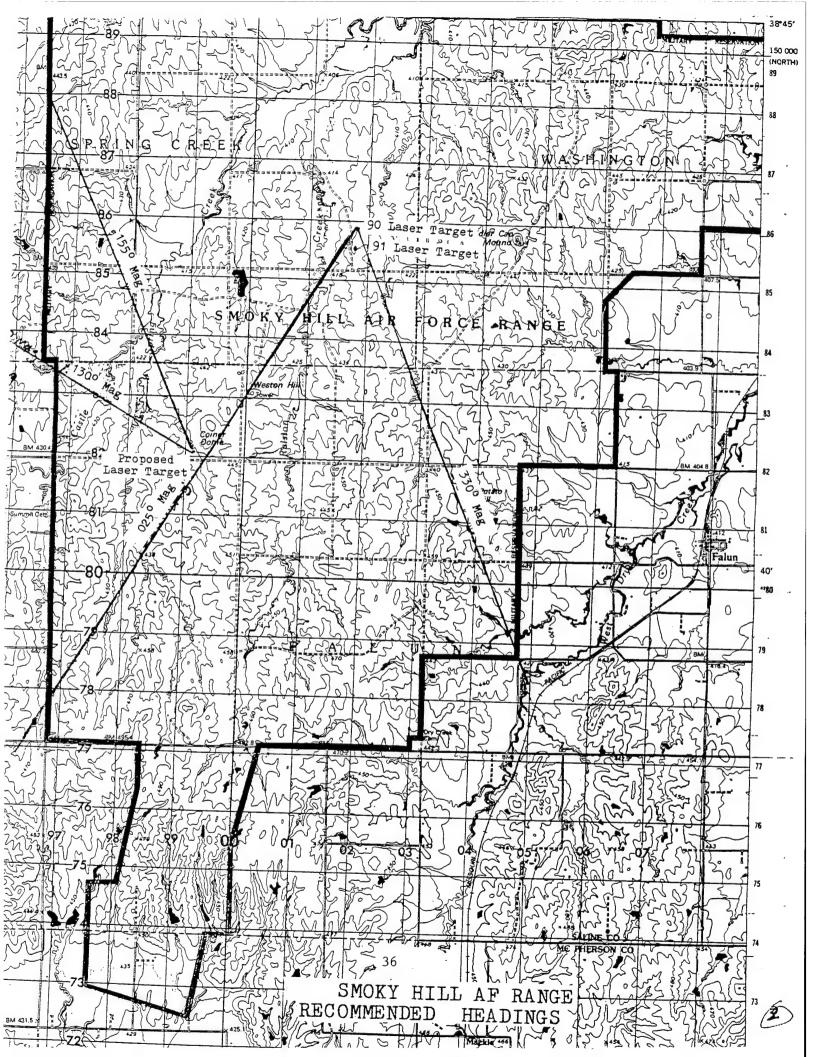
of required at the laser aperture			
Wavelength (nm)	Exposure Time (s)	Ocular OD	Skin OD
1064.0 1064.0 1064.0 1064.0 1064.0	Single Pulse 0.25 10.0 30,000 1.000	4.97 5.15 5.55 6.42 5.30	1.05 1.05 1.35 1.35 1.05
	OD Required at 1.0 km		
Wavelength (nm)	Exposure Time (s)	Ocular OD	Skin OD
1064.0 1064.0 1064.0 1064.0 1064.0	Single Pulse 0.25 10.0 30,000 1.000	0.15 0.32 0.72 1.59 0.47	0.00 0.00 0.00 0.00 0.00
	OD Required at 5.0 km		
Wavelength (nm)	Exposure Time (s)	Ocular OD	Skin OD
1064.0 1064.0 1064.0 1064.0	Single Pulse 0.25 10.0 30,000	0.00 0.00 0.00 0.20	0.00 0.00 0.00 0.00

APPENDIX C

Range Maps



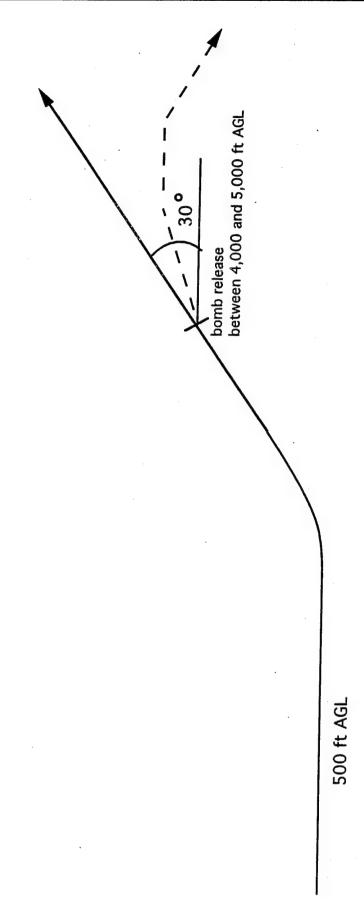




APPENDIX D

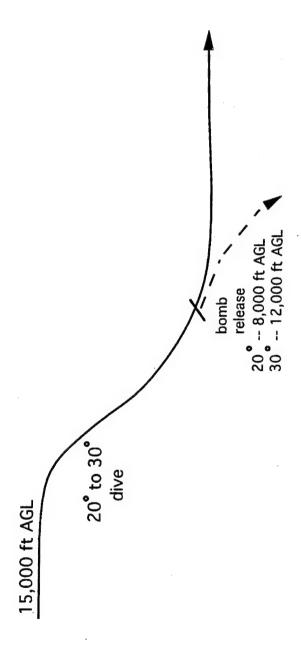
Delivery Profiles

## LOFT DELIVERY PROFILE



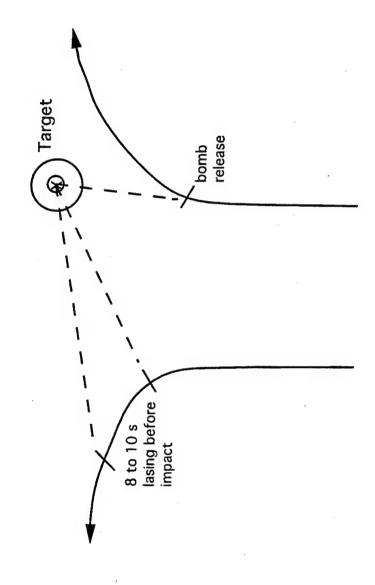
(Side View)

## MEDIUM ALTITUDE PROFILE



(Side View)

## "BUDDY LASE" PROFILE



APPENDIX E

Footprint Calculations

LASER FOOTPRINT TABL

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RI o E :	i	1	FOOTPRINT		, , , , , , , , , , , , , , , , , , , ,	FORWARD	F. C.	WE T		FORWARD		AFT		FORWARD		AFT			FORWARD		AFT		FORWARD		AFT			FORWARD		AFT		FORWARD		
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Divergence= .18 mrad Table based on: Flat terrain, Buffer= 2 mrad, Diverger NOHD= 22700 meters ( 74456 feet or 12.3 nautical miles) LASER FOOTPRINT TABLE for: LANTIRN

1 1 1 1 1	Table	Table values	are		RINT	dimen	sion	FOOTPRINT dimensions(feet	and	meters)		!	:
	,	SLANT		RANGE (nautical	utica	l miles,	1 80	feet,	and	meters)	:	1	1
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2000	FORWARD	62	ft.	97	1	140	ft.	191			ft	316	
	AFT	61	ft	296	ft m	43 138 42	ft H	187 187 57	m ft	76 244 75	ft n	96 309 94	f t
5500	FORWARD AFT	56 17 56 17	ft ft m	88 27 87 27	ft m ft	127 39 125 38	ft ft	173 53 171 52	ft ft		H t H t	287 87 281 86	T E T E
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1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	міртн	51	ft.	63	ft.	76 23	ft m	89			ft	114	f t

FOOTPRINT FORWARD- distance beyond target.

FOOTPRINT AFT- distance from target toward aircraft.

FOOTPRINT WIDTH- total width at target. NOTE: -99 indicates an impossible alt./range combination

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LASER FOOTPRINT TABLE for: LANTIRN

Table based on: Flat terrain, Buffer= 2 mrad, Divergence=
NOHD= 22700 meters ( 74456 f. )

NOHD= 22700	meters (	T4456 fe	ın, fee	n, Buffer= 2 feet or 12.3	mrad, nautical	nce=	.18 mrad
Table values	are	PPRINT	dim	FOOTPRINT dimensions (feet	feet and meters		
	i	SLANT	RAN	(na	tical miles, feet,	and	meters)
ALTITUDE (feet)	FOOTPRINT	4.5 27300 8330	NM ft	5.0 30400 9260			
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	AFT	1000 505 1480 451	rt ft m	2060 628 1810 553	ft ft m		
1500	FORWARD AFT	1080 330 1000 306	ft m ft	1340 409 1230 376	ft m m		
2000	FORWARD AFT	804 245 760 232	ft ft ft	996 304 935 285	ft fr m		
. 2500	FORWARD AFT	640 195 611 186	ft m ft	792 241 753 229	ft m ft		
3000	FORWARD AFT	531 162 511 156	ft ft m	657 200 630 192	ft m ft		
3500	FORWARD	454 138	ft	561 171	ft m		

ft	ft	m ft	ft	m ft m	ft	m ft m	ft
541 165	490	149 475 145	435	133 423 129	391	119 381 116	127
ft m		ft m		m tt		m m	ft
439 134	396	385 117	352	107 343 105	316	96 309 94	114
AFT	FORWARD	AFT	FORWARD	AFT	FORWARD	AFT	МІВТН
	4000		4500		2000		1 1

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Divergence= .18 mrad NOHD= 22700 meters ( 74456 feet or 12.3 nautical miles) Table values are FOOTPRINT dimensions(feet and meters) Table based on: Flat terrain, Buffer= 2 mrad, LASER FOOTPRINT TABLE for: LANTIRN

SLANT RANGE (nautical miles, feet, and meters) 30400 ft 9260 m 4.5 NM 27300 ft 8330 m FOOTPRINT ALTITUDE

127 ft 391 ft 355 ft 325 ft tt 39 m 116 m Ε 99 m E 381 106 318 108 119 347 97 ft 114 ft 316 ft ft 263 ft 287 ft 79 m 86 m 35. m 94 m E E 281 309 258 96 80 87 FORWARD FORWARD FORWARD WIDTH AFT AFT AFT (feet) 5000 0009 5500

FOOTPRINT FORWARD- distance beyond target.
FOOTPRINT AFT- distance from target toward aircraft.
FOOTPRINT WIDTH- total width at target.

NOTE: -99 indicates an impossible alt./range combination

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LASER FOOTPRINT TABLE for:

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LASER FOOTPRINT TABLE for: LANTIRN Table based on: Flat terrain, Buffer= 2 mrad, Divergence= .18 mrad NOHD= 22700 meters ( 74456 feet or 12.3 nautical miles)

SIANT RANGE (nautical miles, feet, and measure processes of the construction of the	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	D 1	) ata	alues	are F	OOTPR	INI	dime	nsions(	ė		mete	rs)	; 	: ! !	•
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PORWARD         101 ft         158 ft         229 ft         31 m         48 m         70 m         96 m         126 m         126 m         129 ft         150 m         <	ALTITUDE (feet)	NI	0.8 4860 1480		1. 08 85		1.2 290 220	NA ft	1.4 8510 2590	NM ft	1. 972 296	Ft ft	1. 090	F.t.	220	1
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FORWARD 50 ft 113 ft 154 ft 202 ft 478 ft 5879 ft 113 ft 154 ft 202 ft 256 ft 1179 ft 100 ft 145 m 146 m 179 m 146 m 179 m 146 m 179 m 150		AFT		E +	₹ 6	E	70	, E	10	) H	40	# #	2 0	ft n	65	
FORWARD 50 ft 78 ft 113 ft 154 ft 202 ft 256 ft 317    AFT 15 m 24 m 34 m 47 m 61 m 78 m 97    15 m 24 m 34 m 47 m 65 m 75 m 97    15 m 24 m 34 m 47 m 65 m 75 m 97    15 m 25 ft 109 ft 119 ft 194 ft 201    AFT 33 ft 52 ft 75 ft 102 ft 133 ft 169 ft 209    FORWARD 25 ft 39 ft 56 ft 76 ft 100 ft 126 ft 156 m 22 m 30 m 40 m 50 m 62 m 62 m    FORWARD 20 ft 31 ft 45 ft 61 ft 98 ft 124 ft 155 m 14 m 15 m 24 m 31 m 38 m 48 m 12 m 13 m 18 m 24 m 30 m 37 m 37 m 37 m 30 m 33 m 33 m 34 m 35 m 37 m 30 m 33 m 33 m 34 m 35 m 37 m 30 m 33 m 37 m 37 m 30 m 33 m 37 m 37				J E	0 <del>4</del>	n m	216	ft m	တေ	ft m	8	ft	7 7	ft	1 00 1	
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FORWARD 33 ft 75 ft 109 ft 149 ft 244 ft 301  FORWARD 33 ft 52 ft 75 ft 102 ft 133 ft 169 ft 209  AFT 33 ft 51 ft 75 ft 100 ft 133 ft 164 ft 201  AFT 25 ft 39 ft 56 ft 76 ft 100 ft 126 ft 202  FORWARD 25 ft 39 ft 55 ft 76 ft 100 ft 126 ft 156  AFT 25 ft 39 ft 55 ft 75 ft 98 ft 124 ft 155  FORWARD 20 ft 31 ft 45 ft 60 ft 78 ft 99 ft 125  AFT 20 ft 31 ft 44 ft 60 ft 78 ft 99 ft 101 ft 125  AFT 20 ft 31 ft 44 ft 60 ft 78 ft 99 ft 101 ft 125  AFT 20 ft 31 ft 44 ft 60 ft 78 ft 99 ft 101  FORWARD 17 ft 26 ft 37 ft 50 ft 65 ft 84 ft 104  AFT 25 ft 37 ft 51 ft 50 ft 65 ft 84 ft 104  AFT 20 ft 31 ft 44 ft 60 ft 78 ft 99 ft 122  FORWARD 17 ft 26 ft 37 ft 50 ft 65 ft 84 ft 104  AFT 25 ft 37 ft 50 ft 65 ft 84 ft 104  AFT 25 ft 37 ft 50 ft 65 ft 84 ft 103  FORWARD 14 ft 22 ft 37 ft 50 ft 65 ft 89  FORWARD 14 ft 22 ft 32 ft 32 ft 77 ft 52 ft 72 ft 89				Ħ		ı m	in	, 5	9 4	ב ב	<b>9</b> 4	tt :	S	ft	$\vdash$	4
FORWARD 33 ft 52 ft 75 ft 102 ft 133 ft 169 ft 209  AFT 10 m 16 m 23 m 33 m 45 m 55 m 75 m 92  AFT 10 m 16 m 22 m 30 m 14 m 52 m 64  FORWARD 25 ft 39 ft 56 ft 76 ft 100 ft 126 ft 156  AFT 25 ft 39 ft 55 ft 75 ft 30 m 39 m 48  FORWARD 20 ft 31 ft 45 ft 61 ft 80 ft 101 ft 125  AFT 20 ft 31 ft 44 ft 60 ft 78 ft 91 m 31 m		AFT		ft		ft	0	£t.	, 4	ft.	0 0	E +	-	E 4	6	=
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FORWARD 25 ft 39 ft 73 ft 100 ft 130 ft 164 ft 202  FORWARD 25 ft 39 ft 56 ft 76 ft 100 ft 126 ft 156  AFT 25 ft 38 ft 55 ft 75 ft 98 ft 124 ft 152  FORWARD 20 ft 31 ft 45 ft 61 ft 80 ft 101 ft 125  AFT 20 ft 31 ft 44 ft 60 ft 78 ft 99 ft 122  B M 13 M 13 M 24 M 31 M 38 M 46  FORWARD 17 ft 26 ft 37 ft 50 ft 84 ft 104  FORWARD 17 ft 26 ft 37 ft 50 ft 65 ft 84 ft 104  FORWARD 14 ft 25 ft 37 ft 50 m 25 m 31 M 37  FORWARD 17 ft 26 ft 37 ft 50 ft 65 ft 84 ft 104  FORWARD 14 ft 25 ft 37 ft 50 m 25 m 31  FORWARD 14 ft 22 ft 32 ft 43 ft 50 m 25 m 31  FORWARD 14 ft 22 ft 32 ft 43 ft 57 ft 89  FORWARD 14 ft 22 ft 32 ft 43 ft 65 ft 89  FORWARD 14 ft 22 ft 83 ft 89  FORWARD 14 ft 22 ft 83 ft 89  FORWARD 15 M 13 M 15 M 22 M 25  FORWARD 14 ft 82 ft 89  FORWARD 14 ft 82 ft 88  FORWARD 14 ft 82 ft 88  FORWARD 15 M 15 M 15 M 22 M 32  FORWARD 14 ft 82 ft 88  FORWARD 15 M 15 M 15 M 25 M 32  FORWARD 15 M 15 M 15 M 15 M 25 M 32  FORWARD 14 ft 82 ft 83 ft 89  FORWARD 15 M 15 M 15 M 15 M 25 M 32  FORWARD 16 M 17 M 18 M 18 M 18 M 32  FORWARD 17 M 18 M 18 M 18 M 18 M 32  FORWARD 18 M 18 M 18 M 18 M 32  FORWARD 18 M 18 M 18 M 18 M 32  FORWARD 18 M 18 M 18 M 18 M 18 M 32  FORWARD 18 M 18 M 18 M 18 M 18 M 32  FORWARD 18 M 18 M 18 M 18 M 18 M 32  FORWARD 18 M 18 M 18 M 18 M 18 M 32  FORWARD 18 M 18 M 18 M 18 M 18 M 32  FORWARD 18 M 18 M 18 M 18 M 18 M 32  FORWARD 18 M 18			10	E	16	ш	23	<b>=</b>	31	נ ק	7	7 T	9 1	Įţ	0	44
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AFT 25 ft 38 ft 55 ft 75 ft 98 ft 124 ft 156  7 m 12 m 17 m 23 m 30 m 39 m 48  7 m 12 m 17 m 23 m 30 m 39 m 48  FORWARD 20 ft 31 ft 45 ft 61 ft 80 ft 101 ft 125  6 m 9 m 14 m 19 m 24 m 31 m 38  FORWARD 17 ft 26 ft 37 ft 51 ft 66 ft 84 ft 104  5 m 8 m 11 m 15 m 20 m 26 m 32  FORWARD 14 ft 22 ft 37 ft 50 ft 65 ft 83 ft 102  FORWARD 14 ft 22 ft 37 ft 50 ft 65 ft 83 ft 102  5 m 8 m 11 m 15 m 20 m 25 m 31  FORWARD 14 ft 52 ft 37 ft 50 ft 65 ft 83 ft 102  4 m 7 m 10 m 13 m 17 m 22 m 27	2000	FORWARD		ft		Į.		ft		ţ		4	•	į	1	
FORWARD 20 ft 31 ft 45 ft 75 ft 98 ft 124 ft 152  FORWARD 20 ft 31 ft 45 ft 61 ft 80 ft 101 ft 125  6 m 9 m 14 m 19 m 24 m 31 m 38  FORWARD 17 ft 26 ft 37 ft 50 ft 65 ft 84 ft 104  5 m 8 m 11 m 15 m 20 m 25 m 31  FORWARD 14 ft 22 ft 32 ft 43 ft 57 ft 72 ft 89  FORWARD 14 ft 22 ft 32 ft 43 ft 57 ft 72 ft 89  FORWARD 14 ft 22 ft 31 ft 41 ft 57 ft 57 ft 72 ft 89		8		E :		Ħ		E		, =	<b>~</b>	֝֝֞֝֝֝֝֞֝֝֝֝֝֝֝֝֝֝֝֝	977	IL	S)	₩
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4500	FORWARD								
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LASER FOOTPRINT TABLE for: LANTIRN Table based on: Flat terrain, Buffer= 2 mrad, Divergence= .18 mrad NOHD= 22700 meters ( 74456 feet or 12.3 nautical miles)

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FOOTPRINT FORWARD- distance beyond target.

FOOTPRINT AFT- distance from target toward aircraft. FOOTPRINT WIDTH- total width at target. NOTE: -99 indicates an impossible alt./range combination

LASER FOOTPRINT TABLE for: LANTIRN Table based on: Flat terrain, Buffer= 2 mrad, Divergence= .18 mrad NOHD= 22700 meters ( 74456 feet or 12.3 nautical miles)

FOOTPRINT         0.8 NM         1.0 NM         1.2 NM         1.1 NM         1.0 NM         1.1 NM         1.1 NM         1.1 NM         1.1 NM         1.2 NM         1.1 NM         1.1 NM         1.1 NM         1.2 NM         1.1 NM         1.1 NM         1.2 NM         1.1 NM         1.2 NM         1.1 NM         1.2		,	NT R	ANGE (n	utica	miles	 feet, a	d meters			\$ 1 1	
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LASER FOOTPRINT TABLE for: PAVE TACK Table based on: Flat terrain, Buffer= 2 mrad, Divergence= 1.8 mrad NOHD= 26600 meters ( 87248 feet or 14.4 nautical miles)

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1000	FORWARD	444 135 414 126	ft m ft	700 213 641 195	ft m ft	2112	ft ft	0747		4 4 9 0	ft ft	14 35 71 01	m ft ft	39 89 46	m ft ft
1500	FORWARD AFT	292 89 279 85	ft m ft m	460 140 433 132	ft ft	9700	ft m ft	47 45	ff # #	0000	ft ft	763 1	ft ft	9 7 0	ft ft
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2500	FORWARD AFT	174 53 169 52	ft ft	272 83 263 80	ft m ft		ft m ft m	2100	ft ft m	0 2 1 0	# ## ##	1 0 C 4 2	e it a	6 4886	ft if
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Divergence= 1.8 mrad NOHD= 26600 meters ( 87248 feet or 14.4 nautical miles) LASER FOOTPRINT TABLE for: PAVE TACK Table based on: Flat terrain, Buffer= 2 mrad,

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LASER FOOTPRINT TABLE for: PAVE TACK

Table values are FOOTPRINT dimensions(f  SLANT RANGE (nautical miles, fee  1.3 NM			ı	1 1 1	1 1 1 1		+ 1	a I	Te					
SLANT RANGE (nautical miles, feet, and meters)		Table	value	are		INI	dim	S	s (fe	י מ	mete			
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66-	66 - 66 -	67 ft 20 m	t. nation
66 -	66 - 66 -	60 ft 18 m	t. rd aircraf ange combi
66 -	66 - 66 -	53 ft 16 m	FORWARD- distance beyond target.  AFT- distance from target toward aircraft.  WIDTH- total width at target.  indicates an impossible alt./range combination
66 -	66 - 66 -	66-	FORWARD- distance beyond targary.  AFT- distance from target tow.  WIDTH- total width at target.  indicates an impossible alt./
AFT	FORWARD AFT	WIDTH	
	15000	2 1 2 1 1 1 1 1	FOOTPRINT FOOTPRINT FOOTPRINT NOTE: -99

LASER FOOTPRINT TABLE for: PAVE TACK Table based on: Flat terrain, Buffer= 2 mrad, Divergence= 1.8 mrad NOHD= 26600 meters ( 87248 feet or 14.4 nautical miles)

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	Ar.T.	15 ft 5 m	24 ft 7 m	34 ft	46 ft	19 m 61 ft	24 m 77 ft	29 m 94 ft	
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LASER FOOTPRINT TABLE for: PAVE TACK Table based on: Flat terrain, Buffer= 2 mrad, Divergence= 1.8 mrad NOHD= 26600 meters ( 87248 feet or 14.4 nautical miles)

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1 1 1 2	WIDTH	66- 66-	35 ft 11 m	42 ft 13 m	49 ft	56 ft		13 m 70 ft
OTPRINT	OOTPRINT FORWARD-							21 m

LASER FOOTPRINT TABLE for: PAVE TACK Table based on: Flat terrain, Buffer= 2 mrad, Divergence= 1.8 mrad NOHD= 26600 meters ( 87248 feet or 14.4 nautical miles)

LANT RANGE (nautical miles, feet, and meters)  10.8 NM	1		1 1 1 1 1	1 1	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1			2	ree	t and m	Deter	(8)			
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LASER FOOTPRINT TABLE for: PAVE TACK Table based on: Flat terrain, Buffer= 2 mrad, Divergence= 1.8 mrad NOHD= 26600 meters ( 87248 feet or 14.4 nautical miles)

SLANT RANGE (nautical miles, feet, and meters)  0.8 NM	1	Ta	ble v	es	are F	OOTPRINT	- p	imensions	- d	1 1 1				;
FOOTPRINT         0.6 NM         1.0 NM         1.2 NM         1.4 NM         1.6 NM         1.7 NM         1.6 NM         1.7		:	SLANT	1 4	 (na	tical	. 0	+	1 7	D				-
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FORWARD         99 <t< th=""><th>(feet)</th><th>FOOTPRINT</th><th>0.8 4860 1480</th><th></th><th>1. 08 85</th><th>NM ft</th><th>1.2 290 220</th><th>1.4 8510 2590</th><th>NM ft</th><th>1.6</th><th>!</th><th>1.8 NM 900 ft</th><th>2.0</th><th>NM ft</th></t<>	(feet)	FOOTPRINT	0.8 4860 1480		1. 08 85	NM ft	1.2 290 220	1.4 8510 2590	NM ft	1.6	!	1.8 NM 900 ft	2.0	NM ft
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LASER FOOTPRINT TABLE for: PAVE SPIKE Table based on: Flat terrain, Buffer= 2.5 mrad, Divergence= .35 mrad NOHD= 10400 meters ( 34112 feet or 5.6 nautical miles)

1	Ta	ble v	alue 	are	Ε,	I d	imen	sions	(1)	and		(s;		:	i i i
	;	SLANT	RAN	(na	utic	l mile	s, f	eet,	pu	eters	1	i		1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	. i
ALTITUDE (feet) 	FOOTPRINT	2.0 12200 3700	NA ft	2.5 15200 4630	NM ft	3.0 18200 5560	NM ft m	3.5 21300 6480	MM ft	4.024300		4.	££.	5.	Ft
0	FORWARD	845 258 742 226	ft ft	1340 1340 410 1140	ft ft	1970 600 1620	ft ft ft	2730 832 2170	tt a tt	3630 1110 2800	# # # # # # # # # # # # # # # # # # #	4680 1430 3490	t a t	9260  \$3730 1140 \$4250	# # # # # # # # # # # # # # # # # # #
1000	FORWARD	408 124 383 117		4 0 0 B		4004	ft ft	5 <b>2 2 2 3 3 4 4</b>	t tit m	2 6 d 8 1	m ft ft	06 16 65 86	ft ft	129 269 81 81	ft m
1500	FORWARD AFT	269 82 258 79		7007		7 7	ft ft	* W 10 L W	ft ft	0 0 0 0	ft #	2 4 4 0 0 0 7 0 0 0 0 0 0 0 0 0 0 0 0 0 0	m ft ft	69 74 53 56	# ###
2000	FORWARD AFT	201 61 194 59		315 96 303 92	ft ft m	455 139 134	ft m ft	7807	ft ft	3 H 4 9 M	it it i	0 4490	######################################	0000	m ft m t
2500	FORWARD	160 49 156 48	ft ft	251 76 243 74	ft ft	363 111 349 106	ft ft m	6 5 7 4	ft m ft	4618	ft ft	2 487 6	######################################	0 21 11 20	E TETE
3000	FORWARD	133 41 130 40	ft ft m	209 64 203 62	ft ft m	301 92 292 89	ft ft	411 125 396 121	ft ft m	538 164 516 157	ft m ft	8050	ft ft	4504	ft ft
3500	FORWARD	114	ft m	178 54	ft m	257 78	ft m	351 107	ft m	460	ft	583 178	ft	00	ft

	AFT	112 ft 34 m	174 ft 53 m	251 ft 76 m	340 ft	443 ft	560 ft	690 ft
0004								
0004	FORWARD							
	AFT	30 m 98 ft	47 m 153 ft	m 69 m				
					298 It 91 m	389 ft 119 m	491 ft 150 m	605 ft
4500	FORWARD			_				
	AFT	27 m 87 ft	42 m	61 m				
				_	266 ft 81 m	346 ft 106 m	437 ft	539 ft
2000	FORWARD							
	AFT	24 m	38 m	55 m	75 m	320 ft 98 m	406 ft 124 m	
								486 ft
	WIDTH	65 ft	81 ft	98 ft	114 ft	130 ft		
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	9 :	- 1			40 m	45 m	50 11
FOOTPRING	FOOTPRINT FORWARD- G.	distance bey	vond target		1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	•

Divergence= .35 mrad Table based on: Flat terrain, Buffer= 2.5 mrad, Divers NOHD= 10400 meters (34112 feet or 5.6 nautical miles) LASER FOOTPRINT TABLE for: PAVE SPIKE

	,	SLANT	RANG	RANGE (nautical	ıtica	al miles,	feet, and	meters)	1 1 1 1 1 1 1 1 1	1 1 3 1 1	1
ALTITUDE (feet)	FOOTPRINT	2.0 12200 3700	NM ft m	2.5 15200 4630	NA ft	3.0 NM 18200 ft 5560 m	3.5 NM 21300 ft 6480 m	4.0 NM 24300 ft 7410 m	4.5 NM 27300 ft 8330 m	5.0 30400 9260	: Et a
5000	FORWARD	79	ft	124		1		4		503	
	AFT	24	m f t	38	E +	55 m				153	
		24	. =	37			239 It 73 m	312 ft 95 m	394 ft 120 m	486	
5500	FORWARD	72	ft	113	ft					757	
		22	E	34	E	50 m				139	
	AF.T.	7.1	1	111	ĻĻ					442	
		22	E	34	Ħ	49 m	m 99	87 m	109 m	135	1 1
0009	FORWARD	99		104						417	
		20		32						122	
	AFT	99	ft	102	ft	147 ft	200 ft	261 ft	329 ft	406	£ #
		0.7		31						124	
	WIDTH	65	ft	81	ft	98 ft	114 ft	130 ft		163	
1 1 1 1 1 1	1	07		<u> </u>				40 m	45 m	20	E

FOOTPRINT FORWARD- distance beyond target.
FOOTPRINT AFT- distance from target toward aircraft.
FOOTPRINT WIDTH- total width at target.

NOTE: -99 indicates an impossible alt./range combination

LASER FOOTPRINT TO

Table values are FOOTPRINT dimensions(feet and meters)  SIANT RANGE (nautical miles, feet, and meters)  13 NA 1.7 NA 1.9 NA 2.1 NA 2.1 NA 2.3 NA 2.410 m 3520 m 3520 m 4260 m 3520 m 3600 m 4260 m 3520 m 3600 m 4260 m 3600 m 3600 m 4260 m 3600 m 10 m	Table values are FOOTPRINT d  SLANT RANGE (nautical  1.3 NM	mens mile 1.7 300	ions (f					
SLANT RANGE (nautical miles, feet, and meters)   1.5 NM	SLANT RANGE (nautical UDE FOOTPRINT 1.3 NM 1.5 NM 7900 ft 9110 ft 10 2410 m 2780 m FORWARD -99 28 ft 8 m FORWARD -99 28 ft 99 28 ft 8 m FORWARD -99 25 ft 99 -99 8 m  FORWARD -99 -99 -99 AFT -99 -99 -99 FORWARD -99 -99 -99 AFT -99 -99 -99 FORWARD -99 -99 -99 AFT -99 -99 -99 AFT -99 -99 -99 AFT -99 -99 -99 AFT -99 -99 -99	mile 1.7 0300 3150		et a	1	 ter	;	į
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Table values are PootPRINT dimensions (feet and meters)		10400 meters (	( 34	1112	et	1	0.0	autle	=	les)							
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LASER FOOTPRINT TABLE for: PAVE SPIKE Table based on: Flat terrain, Buffer= 2.5 mrad, Divergence= .35 mrad NOHD= 10400 meters ( 34112 feet or 5.6 nautical miles)

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LASER FOOTPRINT TABLE for: PAVE SPIKE Table based on: Flat terrain, Buffer= 2.5 mrad, Divergence= .35 mrad NOHD= 10400 meters ( 34112 feet or 5.6 nautical miles)

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LASER FOOTPRINT TABLE for: PAVE SPIKE Table based on: Flat terrain, Buffer= 2.5 mrad, Divergence= .35 mrad NOHD= 10400 meters ( 34112 feet or 5.6 nautical miles)

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LASER FOOTPRINT TABLE for: F18 LASER Table based on: Flat terrain, Buffer= 5 mrad, Divergence= .1 mrad NOHD= 17000 meters ( 55760 feet or 9.2 nautical miles)

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	AFT	242 703 214	ft m	385 1080 330	r ft m	1850 563 1540 468	ft a ft	2560 780 2060 629	ft ft	3400 1040 2660	ft ft	4380 1330 3320	ft m ft	5510 1680 4040	ft ft
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	AFT	210	ft m	326 99	ft	467	ft m	633 193	ft m	824 251	ft m	1040	ft	1280 389	ft	
4000	FORWARD AFT	189 58 184 56	ft m ft m	297 90 286 87	ft m ft m	429 131 410 125	ft ft	586 179 556 170	ft ft	769 234 724 221	ft ft	977 298 913	ft ft	1210 369 1120	ft ft	
4500	FORWARD AFT	168 51 164 50	ft ft m	263 80 255 78	ft m ft	380 116 366 111	ft ft m		ft m ft	681 208 646 197	m th m	865 264 814 248	######################################	1070 327 1000 305	i ti ii	
2000	FORWARD AFT	151 46 148 45	ft m ft m	236 72 230 70			ft ft ft		ft m ft	611 186 583 178	ft ft m	776 237 735 224	ft ft ft	961 293 205 276	ft ft	
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FOOTPRINT FOOTPRINT FOOTPRINT	FOOTPRINT FORWARD- distance beyond target. FOOTPRINT AFT- distance from target toward FOOTPRINT WIDTH- total width at target.	tance e fro	e beyo om tar th at	nd t get targ	arget. toward et.		aircraft.	1		; ; ;						

FOOTPRINT WIDTH- total width at target.
NOTE: -99 indicates an impossible alt./range combination

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LASER FOOTPRINT TABLE for: F18 LASER Table based on: Flat terrain, Buffer= 5 mrad, Divergence= .1 mrad NOHD= 17000 meters ( 55760 feet or 9.2 nautical miles)

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ft 82 ft 107 ft 136 ft 168 m 25 m 33 m 41 m 51 ft 81 ft 105 ft 133 ft 164 m 25 m 32 m 40 m 50 ft 74 ft 96 ft 122 ft 151 m 22 m 29 m 37 m 46 ft 73 ft 95 ft 120 ft 148 m 22 m 29 m 37 m 46 ft 86 ft 98 ft 110 ft 123 ft 26 m 30 m 34 m 37	9 m 14 m 30 ft 46 ft 9 m 14 m
ft 86 ft 98 ft 110 ft 123 m 45 m 51 m 51 m 51 m 51 m 51 m 51 m 25 m 32 m 40 m 50 m 50 m 22 m 29 m 37 m 46 m 22 m 29 m 36 m 45 m 26 m 30 m 34 m 37 m 45 m 26 m 30 m 34 m 37 m 45 m 26 m 30 m 34 m 37 m 45 m 26 m 30 m 34 m 37 m 45 m 26 m 30 m 34 m 37 m 45 m 26 m 30 m 34 m 37 m 37 m 45 m 36 m 45 m 37 m 45 m 37 m 45 m 37 m 45 m 37 m 37 m 45 m 37 m 3	ft 42
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ft 86 ft 98 ft 110 ft 123 m 26 m 30 m 34 m 27	-99 11 m -99 37 ft -99 11 m
m 26 m 30 m 34 m 32	
	m 19

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LASER FOOTPRINT TABLE for: TRAM Table based on: Flat terrain, Buffer= 5 mrad, Divergence= .1 mrad NOHD= 14600 meters ( 47888 feet or 7.9 nautical miles)

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ALTITUDE (feet)	FOOTPRINT	2.0 12200 3700		2. 520 463	NAM ft	3.0 18200 5560	NA F	3.5	NM ft	4.0	PM ft	4.	NM ft	5.	1 .
200	FORWARD	1700 518 1330 405	ft a ft	2750 839 2020 616	ft ft ft	4110 1250 2830 864	ft ft	5820 1770 3760		7410 7910 2410 4790	ft t		##t ##	9260 13400 4100 7130	ft.
1000	FORWARD	794 242 703 214	ft ft m	1260 385 1080 330	ft ft	1850 563 1540 468	ft ft	56 78 06 62	ft ft ft	400 040 660	ft ft	333333	ft ft	17 51 68 04	
1500	FORWARD AFT	518 158 478 146	ft ft m	819 249 739 225	ft ft	1190 363 1050 321	ft m ft	4000	ft ft	4 6 4 4	ft # #	017777331	ft ft	23 46 05 82	ft ft ft
2000	FORWARD AFT	385 117 362 110	ft ft m	606 185 561 171	ft ft m	879 268 802 245	ft m ft	7 9 8 6	ft ft	0 00 00	ft #	30 118 70	m ft ft	85 76 16	m ft. ft
2500	FORWARD AFT	306 93 291 89	ft m ft	481 147 452 138	ft m ft	697 212 648 197	ft ft m	6 7 9 55	ft ft ft	850 47	ft ft	30 30 36	a ### #################################	9 609	ft ft ft
3000	FORWARD AFT FORWARD		ff m ft m ft	1729	ft m ft m	7749	ft m ft m	789 241 735 224	ft m ft	1040 316 956 291	ft m ft	020	H H H H H H H	40000	m ff #
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FOOTPRINT	FOOTPRINT FORWARD- di	graph	- Postor	1		1	1 1 1				:	<b>5</b> 0	E	94	E	

LASER FOOTPRINT TABLE for: TRAM Table based on: Flat terrain, B

NOHD= 14600	d on: Flat 0 meters (	terrain, 47888 fe		Buffer= or 7.		Diver 1 mile	Divergence= miles)	= .1 mrad	ad		
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		- 66				n r	84 ft 26 m	10		122	ft !
0006	FORWARD					ft	വ	ר 9		110	# #
	AFT	66-		14 m 47 ft 14 m	18 1	n ft m	23 m 74 ft 23 m	400	8 m 1 ft	34 109	ft ft
10000	FORWARD	000		6	4	ft	<b></b>	1 00		n 0	E 4
	AFT	n 6 6 6 6 7		5 5 5 5 5 5 5 5 5 6 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7	16 1 54 16 1	m ft	21 m 67 ft 20 m		25.5 T E T E	0 8 6	H H H
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14000	FORWARD	66-		<b>66</b> -	66. 66.	<b>9</b> 6		00			<b>=</b>

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LASER FOOTPRINT TABLE for: TRAM Table based on: Flat terrain, Buffer= 5 mrad, Divergence= .1 mrad NOHD= 14600 meters ( 47888 feet or 7.9 nautical miles)

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APPENDIX F

General Safety Criteria

### GENERAL SAFETY CRITERIA

The following general recommendations are made to ensure safe laser air-to-ground operations:

Lasers should only be fired at targets for ranging or designating purposes.

Laser operations must be stopped immediately if personnel are observed in the LSDZ, equipment malfunction is observed, target is lost in field of view, or anytime laser safety cannot be assured.

The LSDZs must be free of specular reflectors such as shiny metals, glass, and other mirror-like surfaces to the maximum extent possible. During periodic maintenance of the range, the LSDZs must be policed for specular reflectors.

Make sure that the targets are positioned so that the LSDZs do not extend outside the military range or reservation.

When the laser hazard zones are within a designated weapons and gunnery range, laser warning signs are not required on perimeter fences; however, "access" controls to these laser hazard zones are needed.

Laser safety training is essential for both aircrews and ground personnel. This training is the responsibility of the Range Safety Officer and the support Military Public Health Officer. The assigned flight surgeon and Bioenvironmental Engineering Services can assist in parts of this training. Initial and annual training should be conducted and properly documented. Training material can be obtained from AL/OEOE (SSgt Limburg), DSN 240-4785, at Brooks AFB.

No laser should be fired above the horizon or backstop (i.e., hills, trees, or large targets).

On ranges where ground personnel are present during bombing, strafing, and lasing operations, one must take the following additional precautions to ensure their safety from lasers.

Aircrews must call "Target Acquired" and "Laser ON/OFF" to range control personnel each time they fire the laser.

In the event that the laser beam were allowed to go beyond the LSDZ, the range control tower might be illuminated by the laser; therefore, the tower personnel must be equipped with laser eye protection. The required OD for unaided viewing (meaning bare eyes, no optics used such as binoculars, telescope, etc.) for airborne lasers is 4 for  $\lambda$ =1064 nm. The ODs listed in Table A-1 of Appendix A are for exposure at the laser aperture, and

thus 4 is a quite adequate value (even Pave Tack requires only 2.7 OD at 100-m range per our calculations).

On ranges which are not being controlled, there are usually no personnel present on the ground during flying operations. However, it is possible that certain maintenance projects may be performed on a part of the range while flying and lasing operations occur on another part of the range, so that aircrew training time is reduced as little as possible. In that case, the following precautions must be observed:

- 1. Aircrews must be warned of the presence and location of the ground personnel.
- 2. Ground personnel must not be in the LSDZ of the targets that aircrews are training on.
- 3. Ground personnel on a range, who might be overflown, must be equipped with laser protective eyewear with an OD of 4 for the 1064-nm wavelength, and must absolutely avoid using any type of magnifying optics such as binoculars, telescopes, etc., during laser operations.

The following recommendations concern the use of air-to-ground laser systems:

- 1. When using LANTIRN in the combat or operational mode ( $\lambda$ =1064 nm), and due to the secondary beam, a distance of 150 ft between aircraft must be maintained to ensure the safety of the aircrews while lasing.
- 2. From the tactics that are used, there should not be a need for aircrews to wear laser eye protection as long as aircrafts remain 150 ft from each other, aircrews only lase the targets, and "buddy lasing" is used only in the manner that was described to us (i.e., there is no chance that the bombing aircraft will pass in the beam from the lasing aircraft).

The following recommendations concern the use of ground-to-ground laser systems. However, since we do not have any details at this time on how and where the lasers would possibly be used, we are only including general guidelines.

- 1. Ground-to-ground laser target designators and range finders are classified as either ANSI Class 3 or 4. The procedure to determine the LSDZ is about the same as for air-to-ground lasers. However, the ground-to-ground laser system operator can be closer to the target than an air-to-ground laser system because the ground system can be offset from the aircraft flight path and out of the weapons and laser footprints. Therefore, in addition to specular reflection, one needs to be more concerned with diffuse reflections and skin hazards. Buffer angles also need to be determined differently (see MIL-HDBK-828 or AFOSH 161-10).
- 2. If the laser is fired from an elevated platform, the LSDZ should be evaluated using the same procedures as for air-to-ground lasers.

- 3. If the surrounding terrain is flat or falls off in the distance without backstop, the LSDZ is a cone, consisting of the beam plus the buffer angle, extending out to the NOHD that covers the target area and surrounding areas within the buffer angles.
- 4. If the terrain contains backstops (natural or man-made) which terminate the laser beam within the NOHD, then the LSDZ is contained in that area provided the backstop is high enough to include the beam and the buffer angle. It is therefore a good idea to site the targets in front of backstops.

As far as medical surveillance requirements are concerned, one must consider two different categories of employees: laser personnel and incidental personnel. Laser personnel are defined as working routinely with lasers while incidental personnel are those whose work makes it possible but unlikely that they will be exposed to laser energy sufficient to damage their eyes or skin. All personnel working on laser ranges (i.e., the aircrews and the ground personnel) fall in the category of incidental personnel. For this type of personnel, the medical examination requirements are:

- 1. Required examinations shall be performed prior to participation in laser work, following any suspected laser injury, and after laser employment is completed. Periodic examinations are not required. Please note that medical surveillance is not required for personnel using ANSI Class 1, 2, 2a, or 3a lasers but is required for users of Class 3b and 4 lasers (see Appendix B for laser classifications).
- 2. Only visual acuity measurement is required. This examination should be performed by, or under the supervision of, an ophthalmologist, optometrist, or other qualified physician. Visual acuity for far and near vision should be measured with some standardized and reproducible method. Refraction corrections should be made if required for both distant and near test targets. If refractive corrections are not sufficient to change acuity to 20/20 (6/6) for distance, and Jaeger 1+ for near, a more extensive examination is indicated.
- 3. These medical surveillance requirements are those prescribed by the ANSI Std Z136.1-1993 with an additional post-laser employment medical examination required by the Air Force. The current AFOSH Std 161-10, dated 30 May 1980, contains different requirements, but the new Air Force policy is going to endorse the ANSI Std Z136.1-1993 requirements on the topic of medical surveillance and only requires a laser work termination medical examination in addition. This new policy on laser medical surveillance will soon be made official in a policy letter from HQ AFMOA/SGPA and also by the revised AFOSH Std 161-10 (which will be published as AFI 48-10).

Because all Air Force military personnel receive this type of visual acuity examination when they enter the Air Force, this should be documented in their medical records, and there is no need to give them this examination again. In the case of Air Force civilian personnel there is a need to give them this eye examination if they have not had one

during their Air Force employment, and if they are in activities where they could potentially be exposed to lasers.

# APPENDIX G

Laser Goggle Procurement Information

## GI FNDALE PRODUCTS MEET U.S. AND INTERNATIONAL STANDARDS

Glendale laser eye protection devices are certified to exceed the requirements of both ANSI Z136 and Canadian Z386 standards for protection against both direct or reflected beam impact.

Further, all basic filters are regularly tested by the Federal Physical-Technical-Institute, West Germany and have received DIN and European EN207 approvals. For a product to receive this approval both the frame and lens are subjected to a direct beam hit of 10 seconds from a continuous wave laser, or 100 pulses from a corresponding pulse laser, and must still maintain specific protection factors. Glendale filters certified under this test program are marked with their respective test results.

In the event a filter should receive direct beam impact,

the filter will absorb the radiation for a period of time long enough to allow wearers to remove themselves from the beam path without sustaining eye injuries. The Audio Visual Alert System (AVAS) designed into all filters warns wearers that they are being lased.

All products are permanently marked with the optical density (OD) and laser wavelength(s) against which a filter is designed to protect, a requirement of ANSI 7136.3.

Laser-Gard green CO<sub>2</sub> and Nd-YAG filters provide protection against secondary harmful radiation created by welding and cutting. Clear or other finted plastic filters and clear glass do not.

## KEEPING PACE WITH THE NEW APPLICATIONS OF LASERS

As new applications emerge, Glendale is usually one step ahead working on laser absorbers that will protect against the wavelengths and other characteristics of the new lasers. In industry, diode-equipped Nd-YAG, high power diode, excimer and copper vapor can offer capabilities to create new processes and improve old ones. In medicine, laser

diode arrays will be joining NdMO, nolmium, excimer and erbium lasers as effective surgical devices.

Glendare is constantly expanding the base library of its absorber technology to custom design protective filters for new single-time and combination multi-wavelength laser systems.

## GLENDALE LIGHT MANIPULATION SYSTEMS MAKE LIGHT WORK FOR YOU

The applications of light manipulation technology can enhance products and equipment in many areas: commercial, medical and military. Infrared absorptive technology can be used to address manufacturing requirements—to speed processing and improve quality.

Some of the special light manipulation filters available

from Glendale include:

- Visibly Opaque-IR Transparent Filters (Various cut-on wavelengths)
   ANVIS Compatible Filters for Infrared Supression
   Secure Lighting Filters
   Specialty
   Electro-Optic Filters for Automotive and Other Uses
- IR Marking Systems IR Lithography High Quality Sunglass Filters.

## LASER PROTECTION FOR MILITARY PERSONNEL

Glendale is a leader in designing both single and multi-wavelength laser eye protection filters for military personnel. The company provided the first laser filter to the military in 1968 and has continued since then to develop enhanced filters to meet the more sophisticated modern day battle field needs for both daytime and nighttime operations.

The laser absorbers can be processed in various polymers to meet special design needs. When processed in polycarbonate the filters meet military ballistic and pilot ejection wind blast requirements. The same filters can be used on vehicles such as tank viewing ports to protect personnel and sensitive equipment inside.

Glendale laser specialists can help you. For assistance call toll-free 1-800-500-4739





**BILSOM GROUP** 

5300 Region Court, Lakeland, FL 33801 TOLL-FREE: 800-500-4739/813-687-7266/FAX: 813-687-0431



#### LPS Laser Plastic Spectacle Stylish, Adjustable Eyewear

DVO" (diffuse viewing only) laser eyewear from uvex provides excellent protection against stray tight from today's most common lasers. It is available in 3 attractive frame styles. The LPS (laser plastic speciacle) features adjustable temples and an inclination system for a customized fit. Wraparound styling with a wide unilens design provides panoramic vision. All models feature uvex's exclusive optidura 4C Plus coating. This permanently bonded anti-fog, anti-scratch coating provides clear vision even in humid environments.

Circle 245



#### L2001 OTG Spectacle Over-The-Glass Spectacle

Introducing the **L2001**, the industry's first **OTG** (over the glass) laser spectacle. This light weight, impact resistant polyce bonate eyewear can be worn comfortably over your prescription glasses, or as a stand alone spectacle. It is ideal for vaitors or for people who dislike goggles - a truly universal product. The **L2001**, (as well as all other **DVO laser eyewear** from **uvex**) is laser inscribed with the name of the laser, the wavelength, and the optical density on the front of the lens for easy identification.

Circle 246



#### LPG Laser Plastic Goggle Comfortable, Fog Free Goggles

The **DVO LPG** (laser plastic goggle) features a soft, flexible PVC body that fits comfortably over Rx glasses. The sportstyle sealing flange and "accordion pleat" nasal area assure longwearing comfort. **uvex**'s exclusive **optidura 4C Plus** coating, combined with a unique indirect venting system, offer a cool fit. All **DVO** lenses have the laser absorptive dye uniformly dispersed throughout the lens which consists of 100% impact resistant polycarbonate and meets ANSI Z136.1-93, and ANSI Z87.1-89

Circle 247



## LO2 Series The Industry Standard

The LO2 spectacle is our most popular LGT design. The lightweight, contionable frame is equipped with wire core temples for complete adaptability. The option of inserting prescription lenses makes this many matter state of the sheet little types for virtually any application. Custom-made filters are available upon request.

Circle 248



#### LO3 Goggle Long-Lasting OTG Comfort

This flexible, reliable goggle is fitted with strategically located head straps and with solt face foam to provide long lasting comfort. Grooves inside the goggles allow you to wear this model over prescription glasses with a pressure-free fit. All of our LGT models are clearly laser inscribed with optical density and corresponding wavelength for easy identification.

Circle 249



DAIMLERSTR 26 D-91301 FORCHHEIM GERMANY PHONE. +49-9191-2061 FAX +49-9191-66913

# uvex LGT laser eyewear: Clearly Superior



uvex laservision introduces a completely redesigned line of laser glass technology (LGT) eyewear, focusing on your concerns for improved comfort, fit, and visibility. Our filters optimize visible light transmission by tailoring the optical densities to your specific applications.

All uvex laser lenses are designed to meet ANSI Z136.1. uvex laservision LGT lenses also meet the stringent European norms that calculate optical density using direct laser radiation.

The LO5 series spectacle features a

large curved glass lens in a wraparound frame. This panoramic design is enhanced with adjustable temples and an inclination system for a customized lit.

Our new **LO6** goggle is fog-free due to its unique air flow design. The new clip-on strap facilitates donning of the goggle. Personalized adjustment pads maximize comflort and are easily cleaned or sterilized.

**uvex laservision**, helping you see clearly and safely into the 21st century and beyond.

UVEX SAFETY,LLC 10 Thurber Blvd. Smithfield, RI 02917 (401)232-1200 (800)343-3411 fax (401)232-1830



# LIST OF LASER PROTECTION EYEWEAR MANUFACTURERS OR VENDORS

American Optical Company Safety Products Group 14 Mechanics Street Southbridge, MA 01550 Telephone: 508-765-9711

Ealing Electro-Optics, Inc. New Englander Industrial Park Holliston, MA 01746 Telephone: 508-429-8370

Edmund Scientific
Edmund Building
Publications Department
Barrington, NJ 08007
Telephone: 609-547-3488

Energy Technology, Inc. P.O. Box 1038 San Luis Obispo, CA 93406 Telephone: 805-544-7770

Fish - Schurman Corporation P.O. Box 319 New Rochelle, NY 10802 Telephone: 914-636-1300

General Scientific Equipment Co. 525 Spring Garden
Philadelphia, PA 19123
Telephone: 215-922-5710

Glendale Protective Technologies 130 Crossways Park Drive Woodbury, NY 11797 Telephone: 516-921-5800

Omicron Eye Safety Corporation 73 Main Street Brattleboro, VT 05301 Telephone: 802-257-7363 Phase-R Company Box G-2 New Durham, NH 03855 Telephone: 603-859-3800

Fred Reed Optical P.O. Box 27010 Albuquerque, NM 87125-7010 Telephone: 505-265-3531

Rockwell Associates, Inc. P.O. Box 43018 Cincinnati, OH 45243 Telephone: 513-271-1568

U.S. Laser Corp. P.O. Box 609 825 Windham Ct. N. Wychoff, NJ 07481 Telephone: 201-848-9200

U.V.P., Inc. P.O. Box 1501 San Gabriel, CA 91778 Telephone: 818-285-3123

UVEX Winter Optical, Inc. 10 Thurber Blvd.
Smithfield, RI 02917
Telephone: 401-232-1200

# APPENDIX H

DoD Laser Range Survey Checklist

# DOD LASER RANGE SURVEY

# PRESURVEY CHECKLIST

			RANGE (SHANGR)	
DATE:	Sept	: 1994		
LOCATION (GRID COORDINATES):  ADDRESS: Salina KS 67401 PLANNED SURVEY: DATE: Nov. 1994				
ADDRESS: Sa.	lina kb b	401	PLANNED	SURVEY:
DAIE:	1994			
			LAST SURVE	Y DAME.
PHONE: DSN:	743-750	00	PERFOR	
PHONE: DSN: COMM:	(913) 82	7-9611	PERFOR	GIED BI.
RANGE POC:	Maj. An	nes	•	
USER POC'S:				
		DATA COL	LECTION	
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OLD SUR	VEI REPORT			
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			<del></del>	
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		R OPERATION		
SHIP MOU	INTED LASE	R OPERATION	s	
SYSTEMS TO BE				
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I D_02	CVIIID	W6032	DAME MAGNAVA	ATTA . C
TD-82	GATTD	MOUAZ	PAVE TACKXXX	GVS-5
MEDAS	M1 3 1	M55131	PAVE SPIKE XX	WILES:
MOUND	MIAI	MJJIRI	PAVE SPIKE AA	MILES
TADS XX	T.ልልጥ YY	CT.D	PAVE KNIFE	F/3-10
			TAVE RUITE	r/A-18
MMS				
OTHERS (LIST) F-117				
<u>F'-11/</u>				

# TARGET NAME

# GRID COORDINATES

3. "91" Stacked Dumpsters N3842.867 W9749.672  4	1	· <u>"90"</u>	Stacked	Dumpsters	N3842.986 W9749.757 (WGS-84)	
6. 7. 8. 9. 10.  LASER OPERATOR/FIRING POSITIONS FOR TARGET #?  1. 2. 3. 4. 5. 6. 7. 8. 9. 10.  FORWARD OBSERVER POSITIONS FOR TARGET #?/LASER #?  GRID COORDINATES  1. 2. 3. 4. 5. 6. 7. 8. 9. 10.	3	1911	Stacked	Dumnatona	W3040 067 W0740 670	
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8. 9. 10.  LASER OPERATOR/FIRING POSITIONS FOR TARGET #?  1. 2. 3. 4. 5. 6. 7. 8. 9. 10.  FORWARD OBSERVER POSITIONS FOR TARGET #?/LASER #? GRID COORDINATES  1. 2. 3. 4. 5. 6. 7. 8. 9. 9. 10.						
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7						
8. 9.						
9.						

	<u> </u>
If Yes	o, what are they?  OOS Magnetic
Will n	more targets be added? Yes XX No
If yes	s, where? grid coordinates Coiner Dome
Are th	here manned positions on the range? Yes $XX$ No
If so,	, where? grid coordinates
Are th	here any conditions off the range that need to be
addres	
addres Yes _	XX No
addres Yes If yes	XX No  s, what? Salina KS, Falun, KS, Smolan, KS, and along with Salina Airport are all located
Yes If yes Bavar the E	XX No  s, what? Salina KS, Falun, KS, Smolan, KS, and ria, KS along with Salina Airport are all located last side of the Smoky Hill Range.
Yes If yes Bavar the E	XX No  s. what? Salina KS. Falun. KS. Smolan. KS. and
Yes If yes Bavar the E	XX No  s, what? Salina KS, Falun, KS, Smolan, KS, and ria, KS along with Salina Airport are all located last side of the Smoky Hill Range.
addres Yes If yes Bavar the E	XX No  s, what? Salina KS, Falun, KS, Smolan, KS, and ria, KS along with Salina Airport are all located east side of the Smoky Hill Range. Flight profiles must avoid these areas.
addres Yes If yes Bavar the E	XX No  s, what? Salina KS, Falun, KS, Smolan, KS, and ria, KS along with Salina Airport are all located last side of the Smoky Hill Range.
addres Yes If yes Bavar the E	XX No  s, what? Salina KS, Falun, KS, Smolan, KS, and ria, KS along with Salina Airport are all located east side of the Smoky Hill Range. Flight profiles must avoid these areas.
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Any of	XX No  s, what? Salina KS, Falun, KS, Smolan, KS, and ria, KS along with Salina Airport are all located that side of the Smoky Hill Range. Flight profiles must avoid these areas.  ther changes
addres Yes If yes Bavar the E	XX No  s, what? Salina KS, Falun, KS, Smolan, KS, and ria, KS along with Salina Airport are all located that side of the Smoky Hill Range. Flight profiles must avoid these areas.  ther changes

### ON-SITE CHECKLIST

1.	Laser Safety Officer  Maj. Ames		
	Address SHANGR 8429 West Farrelly Rd. Salina, KS 67401-9407		
	Phone (DSN) 743-7500		
2.	Is there a Laser Safety Officer on range during laser operations?		
	Yes XX No		
3.	Have all of the range personnel involved with laser operations had laser safety training?		
	Yes No Some		
4.	Is there a medical surveillance program in place?		
	Yes XX No Through McConnell AFB		
5.	Have all of the lasers being used on the range been evaluated by the specific service agency in Chapt 1 para Ala?		
	Yes No $XX$		
6.	Is the range adequately fenced to prevent unauthorized entry?		
	YesXX No		
7.	Are laser warning signs posted at the range boundaries and at the entrance?		
	Yes No At the entrance		
8.	Are there barricades with laser warning signs?		
	Yes No New procedure		
9.	If necessary, are the laser warning signs multilingual?		
	Yes No XX		

10.	Are the targets made of a non-reflecting material for the laser wavelengths being used on the ranges?
•	Yes XX No
11.	Are the target and target areas free of specular reflectors?
	Yes XX No Very well Groomed
12.	Is there a protective eyewear training, inspection and replacement program in place?
	Yes XX No need protective covers
13.	Are all of the personnel who must be on the range during laser operations equipped with the proper eye protection?
	Yes XX No
14.	Is a laser operations log or schedule containing the date, time and heading of all laser operations being kept?
	Yes No New procedure
15.	Is there two-way communication between the range laser safety officer, laser system operators and range personnel?
	Yes <u>XX</u> No
16.	Describe the surveillance of the range.  Good communications with air and ground parties
	Traffic control is monitored at the entrance and by the RCO.

### REVIEW OF RANGE SOP AND/OR LASER SAFETY INSTRUCTION

	boes sor or Laser Safety Instruction specify:
(a)	Permissible aircraft flight profiles and run-in headings for specified targets or target areas.
	Yes XX No
(b)	Permissible ships headings and safe firing zones for specified targets or target areas.
	Yes No
(ċ)	Permissible ground-based laser operating positions and/or areas for specified targets or target areas.
	Yes No Surveyed for new procedures.
(d)	Hazard areas to be cleared of non-operating personnel (roadblocks if required).
	Yes XX No
(e)	Operating personnel locations (indicating those requiring eye protection).
	Yes No
(f)	Types of surveillance to be used to ensure a clear range.
	Yes XX NoSchedules and communications
(g)	Radio frequencies for communication where appropriate.
	Primary UHF 316.9 Back-up 304.9 Primary VHF 139.7
(h)	Firing log/schedule is kept by the range officer in accordance with DOD safety and health record keeping regulations.
	Yes No New procedure
(i)	Laser systems will not be activated until the target has been positively identified.
	Yes No New procedure

(j)	All class 3 and 4 lasers shall not be directed above the horizon unless coordinated with all DOD components including NORAD (DSN: 834-1211 Ext: 3290) and regional service rep to FAA when lasing outside restricted airspace. Has coordination been completed?
	Yes No New procedure
(k)	For ground-based lasers, all unprotected personnel must remain behind the laser operator. Are these instructions in place?
	Yes <u>XX</u> No
(1)	Personnel in other aircraft in the restricted cone around the laser line of sight have eye protection of the proper wavelength and an optical density as specified in appendix A for the specific system or as approved by the laser safety specialists for that DOD component.
	Yes <u>XX</u> No

# RANGE SURVEY REPORT

lote	: This report may require sign-off by the respective Service Laser Safety Authority.
١.	RANGE/AREA NAME: SMOKY HILL ANG RANGE (SHANGR)
3.	SURVEY SUMMARY:
	Date survey was completed: 7-9 November 1994
	Applicable regulations: AFOSH 161-10, MIL-HDBK 828, RCC 316-
	Range controlled by: 184 TFG, Kansas ANG, McConnell AFB, K
	Survey completed by (name/organization): Boyd C. Barker/AL/C
	Dates of operations for which survey is valid:
	SURVEY RESULTS:  1. Degree of compliance with applicable regulations  Laser procedures were available and are in the process of up-date with the results of this survey.
	2. Safety deficiencies that must be corrected before approving range for laser use Laser footprints must be added to the range maps. Laser communications terminology must be added to the laser range procedures.
	RECOMMENDED ACTIONS:  1. Corrective actions for existing deficiencies  Add footprints and communications terminology to the  new procedures.

### 2. Ground Laser Restrictions

Description of Laser Surface Danger Zones (LSDZ) A proposed site was selected for ground lasing and helicopter operations. The site is near Coiner Dome, in a low valley with rolling hills and forest for a back-stop. Higher terrain on the approach side allow for a look-down with the lasers and there is five kilometers beyond the target area which is remaining in the range. Recommended headings are 130-155 deg Mag. Aircraft Mounted Lasers 3. Description of Laser Surface Danger Zones (LSDZ) The Pave Tack loft (Worst Case) footpring will contain all of the present laser frofiles being used by the Air Force. The footprint is a 6500 foot radius circle around each target. Recommended approach headings are between 3300 and 0250 magnetic. Recommended operating procedures/range regulations Communicate with the aircrews for "Target Acquired" then the RCO/RSO can provide "Clear to Lase" followed by "Laser ON & laser OFF" by the aircrew. Recommend the users/customers visit the range to provide their desired flight profiles and to assure compatibility with the range procedures and terrain. Recommended laser eye protection 5. Laser eye protection was adequate. Recommend using covers or containers to avoid scratching and degredation of the eye wear. Controls for protection from reflected laser beams The range was groomed exceptionally well and the targets are made of materials which will not be reflective. Small ponds of water exist which should be of minimul consequence.

7. Recommended training
No Formal laser training. Recommend support from the
Bioenvironmental Engineering and Flight Surgeon at
McConnell AFB, KS. Guidance can also be obtained from
AL/OEO at Brooks AFB, TX;

8. Recommended prebriefs for

(1) laser users
Recommend laser users visit the range for assuring the compatiblity of flight profiles with the range procedures, and terrain.

(2) laser range personnel
Recommend annual refresher training for all laser support personnel.
Recommend a laser log be maintained. It A schedule of the laser missions is recommended for all laser support

personnel.

# APPENDIX I

Smoky Hill Laser Operations

KANSAS AIR NATIONAL GUARD Hq, 184th Fighter Group McConnell AFB, Kansas 67221-6225

### Training

### WEAPONS RANGES

AFR 50-46, 8 June 1987, is supplemented as follows:

Insert Annex A behind AFR 50-46

EDWARD L SYKES, Colonel, KSANG

Commander

JOHN WRIMEALL, CMSgt, KSANG

Chief, Customer Support

1 Atch Annex A

Supersedes Group Supplement 1 to AFR 50-46, Annex A, 15 October 1989

No of Printed Pages: 48 OPR: DET 1, Hq, 184 FG Approved by: Col Sykes Writer: Major Baxt

Distribution: F, Plus See Distribution Page

### 3-9. LASER OPERATIONS:

- \*a. GENERAL: Laser operations are authorized for use on targets 90 and 91 (Attachment 4). The targets consist of dumpsters stacked together to make each target 20 feet wide and 15 feet high. The southern target (91) is painted white with a dark cross painted on the south side. It is certified for laser use and EDU-33 deliveries. The north target (90) is painted gray and is certified for laser use, and EDU-33s/GEU-10/12 inert deliveries.
- \*b. LASER PROCEDURES: Laser firing will be on the two certified laser targets only. When firing airborne laser systems minimum altitude will be 500' AGL. When dropping GBU-10/12s, and release altitude is above 5000' AGL, a minimum of 25 degrees dive angle is required. There are no run-in heading restrictions for dry laser designation passes. When dropping BDU-33s, aircrew must ensure that they do not overfly or point their nose towards the manned range towers. Inert GBU-10/12s are restricted to a delivery heading from 320 degrees magnetic clockwise to 040 degrees magnetic.
  - c. RESTRICTIONS: The following rules apply for both hot and dry passes.
- (1) Do not lase non-target vehicles. The laser should be pointed at the designated target when the laser is operating.
- (2) Aircrew will immediately terminate laser operations if personnel are observed in the target area.
- (3) Lasers will not be operated if standing water, ice, or snow is within 1200 feet of the target.
- d. LASER TARGET DESIGNATOR SCORING SYSTEM (LTDSS): The AN/DSQ-T34, commonly referred to as the LTDSS is available for dry laser passes to aid in the training and proficiency of aircrew. The portable system will normally be placed on the south side of target (91). If a different position is desired, aircrew will coordinate their request with the RCO. The system may be operated by ground personnel when documented scoring is required. The LTDSS will be unattended with an audible tone pulse transmitted to the designator aircraft on UHF radio frequency of 250.9. The following procedures will apply:
- (1) Units will notify SHANGR NLT COB hours the day prior to the scheduled range period for use of the LTDSS. Mandatory coordination between the flight leader and the RCO is required to ensure proper safety procedures are followed.
- (2) Aircrew will initially make contact with RCO on 316.9 and get clearance to operate on 250.9. Aircrew will check-in on 250.9 with the RCO and run dry passes only. When training is complete, aircrew will return to 316.9.
- (3) If hot passes are desired after use of the LTDSS, approximately 10 minutes is required for removal of the system from the target area.

### 3-10. SIMULATED LASER TARGET (SLT):

- a. Units desiring to use the SLT will contact SHANGR operations personnel one day prior to the scheduled range time.
- b. The SLT will be located approximately 4400 feet south of the flank scoring tower, coordinates 38-40-50N, 97-50-51W. Codes available for use will be 1688, 1626, 1544, 1482 and 1418. Code 1688 will normally be used unless requested otherwise.

### 3-11. THREAT SIMULATORS:

- \*a. Units desiring to use Smoky SAMS and the Sentry Dawg SPS-66 Radar Threat Simulator will contact SHANCR operations personnel one day prior to the scheduled range time. ANG units will coordinate with SHANGR for their allocation of Smoky SAMS during their annual munitions forecast report for the next fiscal year. Their requests will be ordered by SHANCR supply and tracked by range operations. The Smoky SAMS will be directly shipped to the range for use by that particular unit. All other units (Reserve and active duty) will forecast and order their own Smoky SAMS and arrange for transfer of assets with SHANCR during the current fiscal year of use.
- b. The threat simulator will be located and fired from random locations unless specifically requested otherwise. Chaff and flares/Smoky Devils may be dispensed IAW para 3-3h(4), this supplement.
- \*3-12. NOISE ABATEMENT: SHANGR will keep user units informed of noise sensitive areas. These areas should be annotated by units on general briefing materials for aircrew use. Flights will plan tactics and deliveries to avoid these areas. Noise sensitive areas will be avoided by 1NM and/or 1000' AGL. Units will be notified by letter of noise complaints generated by that particular unit.

### 3-13. HELICOPTER OPERATIONS:

- \*a. Range periods will be scheduled IAW para 3-13 of this supplement. Helicopters are not allowed to operate jointly in R-3601A/B with jet fighters unless they are acting as a Forward Air Controller or in a joint pre-coordinated exercise. However, helicopters can work in the Smoky MOAs during flight activities with RCO concurrence. Prior to entering R-3601A/B or the Smoky MOAs (airspace open), flights will obtain clearance from the RCO on 316.9 or 304.9. The RCO will advise incoming flights of your position. Helicopters operating in the vicinity of R-3601 or the Smoky MOAs are encouraged to maintain a listening watch on UHF 316.9 or 304.9. When range time has been coordinated, the following information should be called to SHANCR operations by land line:
  - \*(1) Range period.
    - (2) Number of helicopters.
    - (3) Nature of activity.

# APPENDIX J

Medical Examination Requirements



# DEPARTMENT OF THE AIR FORCE HEADQUARTERS UNITED STATES AIR FORCE



FROM: HQ USAF/SG

1 5 SEP 1993

170 Luke Avenue, Suite 400 Bolling AFB DC 20332-5113

SUBJ: Medical Examination Requirements for Personnel Potentially Exposed to

Laser Radiation (93-016)

TO: ALMAJCOM/SG HQ AFRES/SG

HQ AFIA/SG HQ AFIC/SG HQ AFMPC/DPMM HQ USAF/REM

AFMSA/CC NGB/SG

1. This policy letter implements new laser medical examination requirements based on recommendations in American National Standards Institute (ANSI) publication Z136.1-1993, "American National Standard for the Safe Use of Lasers." This ANSI document supersedes ANSI's 1986 version of this standard, and will ultimately be adopted, with a few exceptions, by the Air Force in a forthcoming revision of AFOSH Standard 161-10 expected to be published in early 1994.

- 2. The current AFOSH Standard specifies medical examination requirements which include a funduscopic examination under mydriasis. The 1986 ANSI Standard deleted this recommendation, and instead recommended individuals having abnormal visual acuity, Amsler Grid or ophthalmoscopic examination of the optic nerve and macula be referred to an ophthalmologist. The 1993 ANSI Standard further refines the 1986 recommendations, deletes the requirement for an ophthalmology examination, and adds a test for color vision.
- 3. Effective with the publication of this policy letter, Air Force medical activities conducting laser medical examinations will accomplish the following:
- a. General. Medical examination requirements are limited to those that are clearly indicated and are based on known risks of a particular kind of laser radiation. Military Public Health (MPH) is responsible for medical surveillance of personnel who work with Class 3b and 4 laser systems. Personnel working with Class 1 through 3a lasers do not require medical surveillance. Individuals under laser medical surveillance will fall into one of the two personnel categories defined below. MPH will determine each employee's category.
- (1) Laser Personnel are those who work routinely in laser environments. These individuals are normally fully protected by engineering controls and/or administrative procedures.
- (2) Incidental Personnel are those whose work makes it possible, but unlikely, that they will be exposed to laser energy sufficient to damage their eyes or skin, e.g., custodial, military personnel on maneuvers, clerical, and supervisory personnel not working routinely in a laser environment.
- b. Frequency of Medical Examinations. For both laser and incidental personnel, pre and post-placement medical examinations will be performed. Periodic examinations are not required. Following any suspected laser injury, the pertinent examinations, as determined by an ophthalmologist, will be performed.

- c. Surveillance Procedures. Complete details are given in Appendix E of ANSI Std 136.1-1993 which is attached. The following minimum surveillance procedures will be adhered to:
  - (1) Laser Personnel:
    - (a) An ocular history will be obtained (E2.2.1).
- (b) An ocular examination will be accomplished and include a check of visual acuity (E2.2.2), Amsler Grid (E2.2.3) and color vision (E2.2.4). The test for color vision will be for purposes of determining a baseline and an individual's ability to work safely in a laser environment.
- (c) If the ocular history shows no problems and visual acuity is found to be 20/20 (6/6 in each eye for far, and Jaeger 1+ for near) with corrections (whether worn or not), and Amsler Grid is normal, and color vision tests are acceptable (see 1.b. above), no further examination is required. Laser personnel with medical conditions noted in the ocular history should be evaluated carefully with respect to the potential for chronic exposure to laser radiation. Any deviations from acceptable performance will require an identification of the underlying pathology either by a funduscopic examination (E2.2.5) or other tests, as determined appropriate by the responsible medical or optometric examiner.
  - (2) Incidental Personnel will have an eye examination for visual acuity.

4. Please disseminate this letter to all ophthalmology, optometry, bioenvironmental engineering, flight medicine and military public health units in your command. Point of contact is Major Don W. Jordan, HQ AFMOA/SGPA, 170 Luke Avenue, Suite 400, Bølling AFB\_DC 20332-5113. DSN 297-0621.

ROBERT A. BUETHE, JR Maior General, USAF, MC

Director, Medical Programs and Resources

Office of the Surgeon General

1 Atch

Appendix E, ANSI Std 136.1-1993

cc: HQ USEUCOM/ECMD

HSC/CC

USCENTCOM/CCSG

#### Medical Surveillance

### E1. Purpose of Medical Surveillance

The basic reasons for performing medical surveillance of personnel working in a laser environment are the same as for other potential health hazards. Medical surveillance examinations may include assessment of physical fitness to safely perform assigned duties, biological monitoring of exposure to a specific agent, and early detection of biologic damage or effect.

Physical fitness assessments are used to determine whether an employee would be at increased or unusual risk in a particular environment. For workers using laser devices, the need for this type of assessment is most likely to be determined by factors other than laser radiation per se. Specific information on medical surveillance requirements that might exist because of other potential exposures, such as toxic gases, noise, ionizing radiation, etc, are outside the scope of this appendix.

Direct biological monitoring of laser radiation is impossible, and practical indirect monitoring through the use of personal dosimeters is not available.

Early detection of biologic change or damage presupposes that chronic or subacute effects may result from
exposure to a particular agent at levels below that
required to produce acute injury. Active intervention
must then be possible to arrest further biological
damage or to allow recovery from biological effects.
Although chronic injury from laser radiation in the
ultraviolet, near ultraviolet, blue portion of the visible, and near infrared regions appears to be theoretically possible, risks to workers using laser devices are
primarily from accidental acute injuries. Based on
risks involved with current uses of laser devices,
medical surveillance requirements that should be
incorporated into a formal standard appear to be
minimal.

Other arguments in favor of performing extensive medical surveillance have been based on the fear that repeated accidents might occur and the workers would not report minimal acute injuries. The limited number of laser injuries that have been reported in the past 20 years and the excellent safety records with laser devices do not provide support to this argument.

#### E2. Medical Examinations

#### **E2.1** Rationale for Examinations

E2.1.1 Preassignment Medical Examinations. Except for examination following suspected injury. these are the only examinations required by this standard. One purpose is to establish a baseline against which damage (primarily ocular) can be measured in the event of an accidental injury. A second purpose is to identify certain workers who might be at special risk from chronic exposure to selected continuouswave lasers. For incidental workers (e.g., custodial, military personnel on maneuvers, clerical and supervisory personnel not working directly with lasers) only visual acuity measurement is required. For laser workers' medical histories, visual acuity measurement, and selected examination protocols are required. The wavelength of laser radiation is the determinant of which specific protocols are required (see E2.2). Examinations should be performed by, or under the supervision of, an ophthalmologist or optometrist or other qualified physician. Certain of the examination protocols may be performed by other qualified practitioners or technicians under the supervision of a physician. Although chronic skin damage from laser radiation has not been reported, and indeed seems unlikely, this area has not been adequately studied. Limited skin examinations are suggested to serve as a baseline until future epidemiologic studies indicates whether they are needed or not.

### E2.1.2 Periodic Medical Examinations.

Periodic examinations are not required by this standard. At present no chronic health problems have beer linked to working with lasers. Also, most uses of lasers do not result in chronic exposure of employees even to low levels of radiation. A large number of these examinations have been performed in the past, and no indication of any detectable biologic change was noted. Employers may wish to offer their employees periodic eye examinations or other medical examinations as a health benefit; however, there does not appear to be any valid reason to require such examinations as part of a medical surveillance program.

E2.1.3 Termination Medical Examinations. The primary purpose of termination examinations is for the legal protection of the employer against unwarranted claims for damage that might occur after an employee leaves a particular job. The decision on whether to offer or require such examinations is left to individual employers.

### **E2.2** Examination Protocols

E2.2.1 Ocular History. The past eye history and family history are reviewed. Any current complaints concerned with the eyes are noted. Inquiry should be made into the general health status with a special emphasis upon systemic diseases which might produce ocular problems in regard to the performance cited in Section 6.1. The current refraction prescription and the date of the most recent examination should be recorded.

Certain medical conditions may cause the laser worker to be at an increased risk for chronic exposure. Use of photosensitizing medications, such as phenothiazines and psoralens, lower the threshold for biological effects in the skin, comea, lens and retina of experimental animals exposed to ultraviolet and near ultraviolet radiation. (See Table E1 for a representative list of photosensitizing agents.) Aphakic individuals would be subject to additional retinal exposure from blue light and near ultraviolet and ultraviolet radiation. Unless chronic viewing of these wavelengths is required, there should be no reason to deny employment to these individuals.

E2.2.2 Visual Acuity. Visual acuity for far and near vision should be measured with some standardized and reproducible method. Refraction corrections should be made if required for both distant and near test targets. If refractive corrections are not sufficient to change acuity to 20/20 (6/6) for distance, and Jaeger 1+ for near, a more extensive examination is indicated as defined in 6.3.

E2.2.3 Macular Function. An Amsler grid or similar pattern is used to test macular function for distortions and scotomas. The test should be administered in a fashion to minimize malingering and false negatives. If any distortions or missing portions of the grid pattern are present, the test is not normal.

E2.2.4 Color Vision Color vision discrimination can be documented by Ishihara or similar color vision tests.

F2.2.5 Examination of the Ocular Fundus with an Ophthalmoscope This portion of the examination is to be administered to individuals whose ocular function in any of Sections E.2.2.1 through E.2.2.4 is not normal. The points to be covered are: the presence or absence of opacities in the media; the sharpness of outline of the optic disc; the color of the optic disc; the depth of the physiological cup, if present; the ratio of the size of the retinal veins to that of the reginal arrevies; the presence or absence of a welldefined macula and the presence or absence of a foveai reflex; and any retinal pathology that can be seen with an ophthalmoscope (hyper-pigmentation, depigmentation, retinal degeneration, exudate, as well as any induced pathology associated with changes in macular function). Even small deviations from normai should be described and carefully localized. Dilation of the pupil is required.

E2.2.6 Skin Examination. Not required for preplacement examinations of laser workers; however, suggested for employees with history of photosensitivity or working with ultraviolet lasers. Any previous dermatological abnormalities and family history are reviewed. Any current complaints concerned with the skin are noted as well as the history of medication usage, particularly concentrating on those drugs which are potentially photosensitizing.

Further examination should be based on the type of laser radiation, above the appropriate MPE levels, present in the individual's work environment.

E2.2.7 Other Examinations. Further examinations should be done as deemed necessary by the examiner.

### E3. Medical Referral Following Suspected or Known Laser Injury

Any employee with a suspected eye injury should be referred to an ophthalmologist. Employees with skin injuries should be seen by a physician.

#### E4. Records and Record Retention

Complete and accurate records of all medical examinations (including specific test results) should be maintained for all personnel included in the medical surveillance program. Records should be retained for at least 30 years.

Table E1

Representative List of Photosensitizing Agents

=		
_	Agent	Reaction
1	Sulfanomide	Phototoxic Photoallergic
2	Suifonylurea	Phototoxic
3	Chlorthiazides	Papular and Edematous Eruptions Plaques
4	Phenothiazines	Exaggerates Sunburn Uniticaria Gray-Blue Hyperpigmentation
5	Antibioucs, e.g., Tetracycline	Exaggerates Sunburn Phototoxic
6	Griscofulvin	Exaggerates Sunburn Phototoxic Photoallergic
7	Nalidixin Acid	Erythema Bullae
8	Furocoumarins (Psoralen)	Erythema Bullea Hyperpigmentation
9	Estrogens/Progesterones	Melasma Phototoxic
10	Chlordiazepoxide (Librium)	Eczema
11	Triazetyldiphenolisatin (Laxative)	Eczematious Photoallergic Reaction
12	Cyclamates	Phototoxic Photoallergic
13	Porphyrins (Porphyria)	Phototoxic
14	Retin-A (Retinoic Acid)	Exaggerates Sunburn Photoallergic

### E5. Access To Records

The results of medical surveillance examinations should be discussed with the employee.

All non-personally identifiable records of the medical surveillance examinations acquired in Section E.4 of these guidelines should be made available on written request to authorized physicians and medical consultants for epidemiological purposes. The record of individuals will, as is usual, be furnished upon request to their private physician.

# E6. Epidemiologic Studies

Past use of lasers has generally been stringently controlled. Actual exposure of laser workers has been minimal or even nonexistent. It is not surprising that acute accidental injury has been rare and that the few reports of repeated eye examinations have not noted any chronic eye changes. For these reasons, the examination requirements of this standard are minimal. However, animal experiments with both laser and narrow-band radiation indicate the potential for chronic damage from both subacute and chronic exposure to radiation at certain wavelengths. Lens opacities have been produced by radiation in the 0.295 to 0.45 μm range and are also theoretically possible from 0.75 to 1.4 μm.

Photochemical reminitis appears to be inducible by exposure to 0.35 to 0.5 µm radiation. If laser systems are developed that require chronic exposure of laser workers to even low levels of radiation at these wavelengths, it is recommended that such workers be included in the long-term epidemiologic studies and have periodic examinations of the appropriate eye structures.

Epidemiologic studies of workers with chronic skin exposure to laser radiation (particularly ultraviolet) are suggested.

#### E7. References

Friedman, A. I. The ophthalmic screening of laser workers. Ann Occup Hyg. 21: 277-279; 1978.

Hathaway, J. A., Stern, N., Soles, E. M., Leighton, E. Ocular medical surveillance on microwave and laser workers. *J. Occup Med.* 19: 683-688; 1977.

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Wolbarsht, M. L., and Landers, M. B. Testing visual capabilities for medical surveillance or to ensure job fitness. *J. Occup Med.* 27: 897-901; 1985.